IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

STATON TECHIYA, LLC, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED Defendant.	Civil Action No. _____ JURY TRIAL DEMANDED

COMPLAINT FOR PATENT INFRINGEMENT

1. Staton Techiya, LLC brings this action for patent infringement under 35 U.S.C. § 271 against Defendant HARMAN International Industries, Incorporated and alleges as follows:

THE PARTIES

2. Plaintiff Staton Techiya, LLC ("Techiya" or "Plaintiff") is a Delaware limited liability company having a place of business at 9501 Jagged Creek Ct., Delray Beach, FL, 33446. It was founded in June 2017.

3. Defendant HARMAN International Industries, Incorporated ("HARMAN" or "Defendant") is a Delaware corporation having a principal place of business at 400 Atlantic Street, Stamford, CT 06901.

THE ASSERTED PATENTS

4. United States Patent No. 8,319,620 ("the '620 Patent"), entitled "Ambient Situation Awareness System and Method for Vehicles," issued on November 27, 2012, to inventors John Usher and John P. Keady. The '620 Patent issued from U.S. Patent App. Ser. No. 12/487,639, filed on June 18, 2009, and was previously published as U.S. Patent Pub. No. 2010/0033313 on February 11, 2010. A true and correct copy of the '620 Patent is attached as Exhibit A.

5. United States Patent No. 11,589,329 ("the '329 Patent"), entitled "Information Processing Using a Population of Data Acquisition Devices," issued on February 21, 2023, to inventor Steven W. Goldstein. The '329 Patent issued from U.S. Patent App. Ser. No. 17/235,130, filed on April 20, 2021. A true and correct copy of the '329 Patent is attached as Exhibit B.

6. United States Patent No. 11,610,587 ("the '587 Patent"), entitled "Personalized Sound Management and Method," issued on March 21, 2023, to inventors Steven Goldstein and John P. Keady. The '587 Patent issued from U.S. Patent App. Ser. No. 17/736,180, filed on May 4, 2022, and was previously published as U.S. Patent Pub. No. 2022/0262361 on August 18, 2022. A true and correct copy of the '587 Patent is attached as Exhibit C. The '620 Patent, the '329 Patent, and the '587 Patent collectively are referred to herein as the "Asserted Patents."

JURISDICTION AND VENUE

7. This action arises under the Patent Act, 35 U.S.C. § 1 et seq.

8. Subject matter jurisdiction is proper in this Court under 28 U.S.C. §§ 1331 and 1338(a) because this is a civil action for patent infringement arising under the federal patent laws of the United States.

9. Defendant is subject to personal jurisdiction in this District by virtue of the fact that it is incorporated under the laws of the State of Delaware.

10. Venue is proper in this Judicial District pursuant to 28 U.S.C. § 1400(b) because Defendant resides within this District as it is incorporated within this District.

ALLEGATIONS OF PATENT INFRINGEMENT

11. Plaintiff incorporates the allegations of the foregoing paragraphs as if fully restated herein.

12. The result of comprehensive research and development, Plaintiff's patented technologies combine many disciplines of acoustic management technology, particularly in the

automotive field, to create solutions that provide exceptional functionality to users for increased safety and comfort.

13. HARMAN provides automotive acoustic management technology systems that, without authorization, implement Plaintiff's patented technologies.

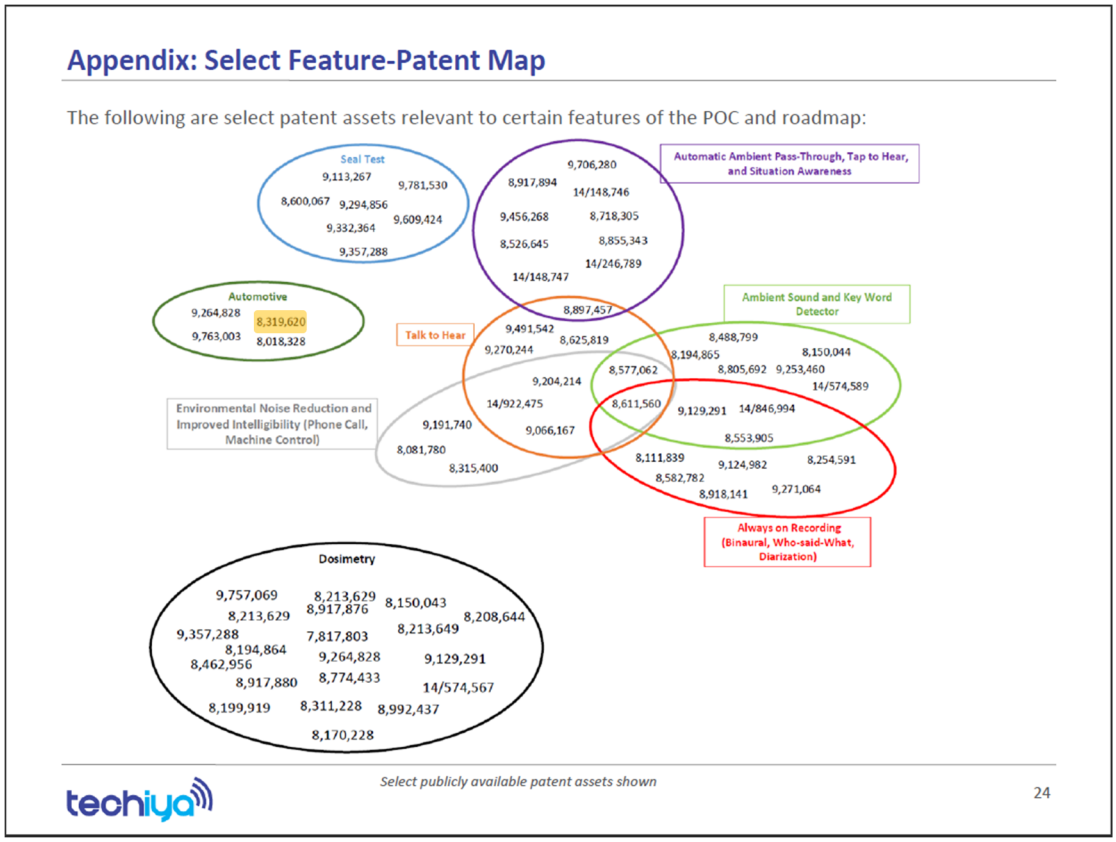
14. No later than February 8, 2019, HARMAN and Plaintiff met to discuss Plaintiff's patented technology and ongoing research and development efforts in the automotive acoustic management technology field and other areas. Plaintiff met with Kevin Hague, the VP of Tech Strategy at HARMAN.

15. Because of their prior intellectual property discussions in related fields, Plaintiff and HARMAN had already consented to a mutual non-disclosure agreement. The mutual non-disclosure agreement protected disclosure of information even to parent entities of HARMAN.

16. Beginning in October of 2018 Plaintiff sent studies, marketing materials, and prototypes to HARMAN.

17. HARMAN reviewed the information received from Plaintiff. Todd Welti (Senior Principal Engineer of Acoustics at HARMAN) conducted various tests on the prototypes that Plaintiff sent to HARMAN. HARMAN subsequently requested additional information and more prototypes. In response, Plaintiff provided additional prototypes and shared proprietary whitepapers.

18. In February 2019, in a follow-up message to a meeting, Plaintiff sent an "Opportunity Overview" slide deck to HARMAN. The deck contained an enumeration of several different advantages offered by Plaintiff's technology and a description of patents relevant to some of the related fields. Some of the Asserted Patents were identified in the deck.



Excerpted slide from deck sent to HARMAN in February 2019. The ’Patent was included in this deck (emphasized in yellow).

19. In March of 2019, Plaintiff met with HARMAN Chief Financial Officer Evelyn Heinbach. The agenda, proposed by Ms. Heinbach, included questions about Plaintiff’s intellectual property and whether Plaintiff could provide demonstrations and technical background on its patented technology.

20. Later that year, on May 15, 2019, Plaintiff presented to HARMAN a comprehensive valuation model of Plaintiff’s intellectual property arranged in a spreadsheet. The spreadsheet contained hundreds of patents and patent applications, categorized by feature and technology.

21. On May 4, 2020, Ms. Heinbach confirmed that “Samsung has done a detailed review of [Plaintiff’s] patent portfolio.” On information and belief, based on this “detailed review,” HARMAN and its parent, Samsung, had knowledge and notice of Plaintiff’s patents that had issued on or before May 4, 2020, including an understanding of the scope of the claims of those patents.

Despite this knowledge HARMAN has infringed, and continues to infringe, patents asserted in this Complaint that were issued prior to May 4, 2020.

22. On May 23, 2020 Ms. Heinbach informed Plaintiff that HARMAN would not be "looking to pursue further steps at this point."

23. On information and belief, despite HARMAN's robust knowledge of the Asserted Patents and Plaintiff's patented technology, HARMAN made the deliberate decision to sell products and services that they knew infringe these patents. HARMAN's continued infringement of the Asserted Patents with extensive knowledge about them constitutes willful infringement.

24. As set forth below, the Accused Product incorporates, without any license or permission from Plaintiff, technology protected by the Asserted Patents. Plaintiff respectfully seeks relief from this Court for Defendant's infringement.

REPRESENTATIVE ACCUSED PRODUCT

25. The representative accused product includes, but is not limited to, HARMAN HALOsonic (the "Accused Product").

26. The HARMAN HALOsonic is an exemplary infringing product.

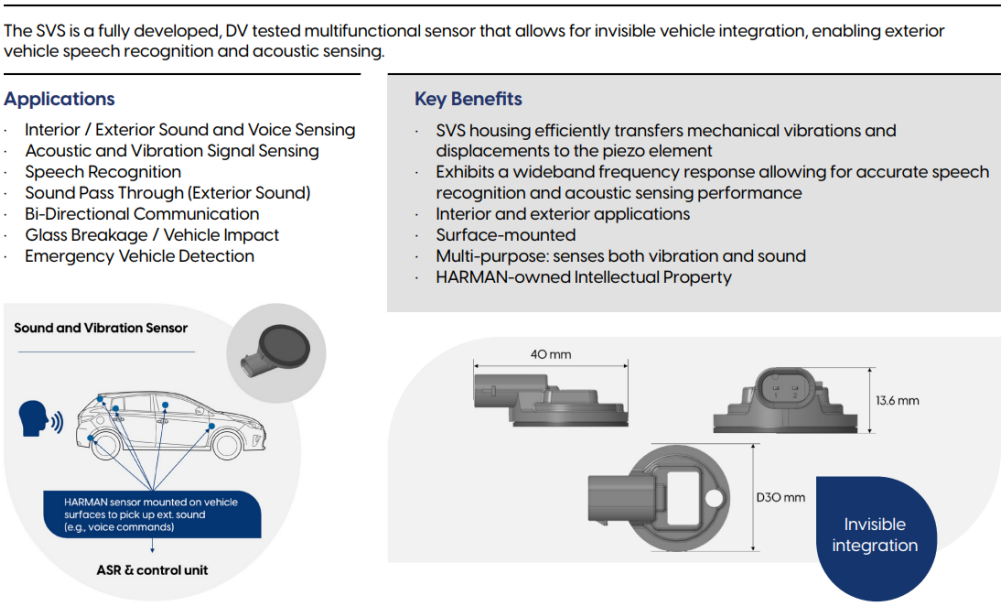
HALOsonic®

HALOsonic is a set of tailormade sound solutions comprised of Electronic Sound Synthesis (ESS), Engine Order Cancellation (EOC), Sound2Target™ (S2T™) and Road Noise Cancellation (RNC).

READ MORE

Source: https://car.harman.com/solutions/car-audio

27. On information and belief, the HARMAN HALOsonic utilizes microphones on the outside of a vehicle to capture external sounds. For example, the HALOsonic utilizes sensors mounted on vehicle surfaces to pick up external sound.



Source: https://info.car.harman.com/harman-sound-and-vibration-sensor

28. On information and belief, the HALOsonic performs Electronic Sound Synthesis (ESS), Engine Order Cancellation, and Road Noise Cancellation (RNC). These features require detecting and analyzing environmental sound captured by the various microphones on the product.

COUNT I

Defendant's Infringement of the '620 Patent

29. Plaintiff incorporates the allegations of all of the foregoing paragraphs as if fully restated herein.

30. Plaintiff is the assignee and lawful owner of the '620 Patent, and Plaintiff holds all right, title and interest in and to the '620 Patent. The '620 Patent is valid and enforceable.

31. Defendant has directly infringed, and continues to directly and willfully infringe, the '620 Patent by making, using, selling, offering for sale, or importing into the United States products that

infringe the ’620 Patent, such as the Accused Product. Further discovery may reveal additional infringing products and/or models.

32. For example, and without limitation, the Accused Product, and similar automotive acoustic management products, infringe at least claim 1 of the ’620 Patent.

33. Defendant has had notice of its infringement of the ’620 Patent at least since February 12, 2019, when Defendant received the aforementioned slide deck from Plaintiff.

34. The Accused Product is an exemplary product that practices at least claim 1 of the ’620 Patent. On information and belief, many other products provided by HARMAN also infringe claim 1 of the ’620 Patent.

35. The ’620 Patent claims: 1. A vehicle situation awareness device for a vehicle comprising: a notification device in the vehicle configured to emit an audio signal; an internal microphone configured to measure an internal acoustic signal in the vehicle; an ambient microphone configured to measure an ambient acoustic signal external to the vehicle; and a processor configured to: determine an internal sound pressure level (SPL) in the vehicle based on the internal acoustic signal, identify at least one sonic signature from the ambient acoustic signal, and when the at least one sonic signature is identified, determine whether to send an emit signal to the notification device to emit the audio signal based on the internal SPL.

36. The Accused Product is an automotive acoustic management system. The system utilizes an array of accelerometers and microphones to generate a desired audio signal within the cabin of the vehicle. HARMAN External Microphones are placed on the exterior of the vehicle and used to capture ambient sound external to the vehicle to produce an ambient sound signal. Internal microphones are used to measure an internal acoustic signal within the cabin of the vehicle. On information and belief, a processor is configured to determine an internal sound pressure level based on the acoustic signal. On

information and belief, the processor also identifies at least one signature sound from the ambient acoustic signal and then determines whether to send an emit signal to the notification device.

The sound you want where you want it

01 **Internal Electronic Sound Synthesis (iESS)**

Enables sound contouring inside the car by creating speed-, acceleration-, and throttle-dependent sounds through the standard speaker system

Advanced synthesis tools allow complete flexibility for "coloring the blank acoustic canvas" offered by todays electric and hybrid vehicle applications, in "all-electric" mode

Sound synthesis during engine-off conditions on Hybrid Electric Vehicles or Range-Extended Electric Vehicles improves perception of engine start-stop events

Improved powertrain feedback makes drivers feel connected to the car they drive

02 **External Electronic Sound Synthesis (eESS)**

Advanced external sound synthesis technologies allow OEMs to define a unique external sound, matching their brand DNA and easily recognizable by anyone on the road

03 **Sound2Target ™**

Combines Active Noise Cancellation and Electronic Sound Synthesis to simultaneously remove unwanted noise content and synthesize or augment desired sound content

Source: https://car.harman.com/solutions/car-audio/halosonic/electronic-sound-synthesis

SOUND2TARGET™

S2T combines Active Noise Cancellation and Electronic Sound Synthesis to simultaneously remove unwanted noise content and synthesize or augment desired sound content. RNC is used to remove broadband content, as well as annoying tire cavity noise and low frequency sound. EOC and harmonic synthesis tools within ESS are then combined to remove unwanted orders and enhance desired order content to achieve the targeted powertrain noise character.

Once an optimized order content or quiet zone is achieved, advanced sound synthesis tools can be used to augment the overall vehicle noise. Features such as looping or triggered wave players, granular synthesis and Shepard tones allow to generate multiple sound layers, including a combination of directed and diffuse noise sources, and obtain the OEM's desired vehicle sound signature.

Source: https://info.car.harman.com/l/606031/2021-08-31/4jwrp/606031/1646751889cKlrUR7S/Brochure_HALOsonic.pdf

37. Defendant has indirectly infringed and continues to indirectly infringe the '620 Patent by actively inducing infringement of the '620 Patent by others, such as users of the Accused Product within this District.

38. Defendant's direct and indirect infringement of the '620 Patent has damaged and will continue to damage Plaintiff.

39. Plaintiff is entitled to recover damages adequate to compensate it for Defendant's direct and indirect infringement.

40. After receiving actual notice of the '620 Patent, Defendant proceeded to make, use, test, sell, and/or offer to sell in this District and elsewhere in the United States, and import into this District and elsewhere in the United States, the Accused Product.

41. On information and belief, Defendant engaged in such activities despite an objectively high likelihood that its actions constituted infringement and inducement of infringement of the '620 Patent. Defendant knew and should have known that its actions would cause direct and induced infringement of the '620 Patent, and on information and belief, Defendant has monitored the substantial prior art submissions made prior to issuance of the '620 patent.

42. Defendant has willfully infringed and continues to willfully infringe the '620 Patent.

COUNT II

Defendant's Infringement of the '329 Patent

43. Plaintiff incorporates the allegations of all of the foregoing paragraphs as if fully restated herein.

44. Plaintiff is the assignee and lawful owner of the '329 Patent, and Plaintiff holds all right, title and interest in and to the '329 Patent. The '329 Patent is valid and enforceable.

45. Defendant has directly infringed, and continues to directly and willfully infringe, the '329 Patent by making, using, selling, offering for sale, or importing into the United States products that infringe the '329 Patent, such as the Accused Product. Further discovery may reveal additional infringing products and/or models.

46. For example, and without limitation, the Accused Product, and similar automotive acoustic management products, infringe at least claim 1 of the '329 Patent.

47. Defendant has had notice of its infringement of the ’329 Patent at least since the date of filing of the complaint in this action.

48. The Accused Product is an exemplary product that practices at least claim 1 of the ’329 Patent. On information and belief, many other products provided by HARMAN also infringe claim 1 of the ’329 Patent.

49. The ’329 Patent claims: 1. A system comprising: a device among a plurality of acoustic devices; wherein the device is configured as a controller, wherein the controller is configured to perform operations comprising: selecting a subset of acoustic devices from among the plurality of acoustic devices for acquiring sensor acoustic data, wherein the subset of acoustic devices are configured to interchange device information and data over a communication link; receiving a first set of sensor acoustic data from a first acoustic device of the selected subset of acoustic devices; receiving a second set of sensor acoustic data from a second acoustic device of the selected subset of acoustic devices; and analyzing at least one of the first set of sensor acoustic data or the second set of sensor acoustic data or a combination of both to identify if speech is present.

50. The Accused Product is an automotive acoustic management system. The system is implemented in the cockpit of a vehicle. The cockpit functions as a controller. HARMAN External Microphones are placed on the exterior of the vehicle and used to capture acoustic data external to the vehicle, for example engine noise, road noise, and speech. Upon information and belief, the captured acoustic data is transmitted to the cockpit over a communication link where it is analyzed to identify speech. Internal microphones can also be used to capture internal acoustic data within the cabin of the vehicle as one of the first or second set of sensor acoustic data for analysis.

Harnessing Sound to Enhance Automotive Experiences

Innovation in today's automotive landscape is all about enabling aspirational consumer experiences at the speed of demand. At HARMAN, we are at the forefront of this bold new era with a host of cutting-edge solutions, like the External Microphone.

With its robust design and easy vehicle integration capabilities, this game-changing acoustic sensor is raising the bar for verbal interaction and situational awareness. External speech recognition, enhanced acoustic detection, increased awareness of approaching vehicles – it's all made possible with the HARMAN External Microphone.

DOWNLOAD DATASHEET

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Source: https://car.harman.com/solutions/car-audio/harman-embedded-audio-external-microphone

HARMAN Sound and Vibration Sensor

HARMAN Sound and Vibration Sensor (SVS) enables automotive OEMs to meet consumer aspirations of speech-controlled convenience and increased situational awareness. A fully developed, DV-tested multifunctional sensor with wideband performance and invisible vehicle integration, SVS enables external speech recognition and acoustic sensing for a multitude of applications.

READ MORE

Source: https://car.harman.com/solutions/car-audio

51. Defendant has indirectly infringed and continues to indirectly infringe the '329 Patent by actively inducing infringement of the '329 Patent by others, such as users of the Accused Product within this District.

52. Defendant's direct and indirect infringement of the '329 Patent has damaged and will continue to damage Plaintiff.

53. Plaintiff is entitled to recover damages adequate to compensate it for Defendant's direct and indirect infringement.

54. After receiving actual notice of the '329 Patent, Defendant proceeded to make, use, test, sell, and/or offer to sell in this District and elsewhere in the United States, and import into this District and elsewhere in the United States, the Accused Product.

55. On information and belief, Defendant engaged in such activities despite an objectively high likelihood that its actions constituted infringement and inducement of infringement of the ’329 Patent. Defendant knew and should have known that its actions would cause direct and induced infringement of the ’329 Patent, and on information and belief, Defendant has monitored the substantial prior art submissions made prior to issuance of the ’329 patent.

56. Defendant has willfully infringed and continues to willfully infringe the ’329 Patent.

COUNT III

Defendant’s Infringement of the ’587 Patent

57. Plaintiff incorporates the allegations of all of the foregoing paragraphs as if fully restated herein.

58. Plaintiff is the assignee and lawful owner of the ’587 Patent, and Plaintiff holds all right, title and interest in and to the ’587 Patent. The ’587 Patent is valid and enforceable.

59. Defendant has directly infringed, and continues to directly and willfully infringe, the ’587 Patent by making, using, selling, offering for sale, or importing into the United States products that infringe the ’587 Patent, such as the Accused Product. Further discovery may reveal additional infringing products and/or models.

60. For example, and without limitation, the Accused Product, and similar automotive acoustic management products, infringe at least claim 1 of the ’587 Patent.

61. Defendant has had notice of its infringement of the ’587 Patent at least since the date of filing of the complaint in this action.

62. The Accused Product is an exemplary product that practices at least claim 1 of the ’587 Patent. On information and belief, many other products provided by HARMAN also infringe claim 1 of the ’587 Patent.

63. The ’587 Patent claims: 1. A system comprising: a user interface; and an audio device comprising: a microphone configured to measure ambient sound and generate a microphone signal; a speaker configured to emit an audio signal; a memory configured to store instructions; an audio buffer configured to store at least a portion of the microphone signal; a data buffer; a processor operatively coupled to the memory, the processor operatively coupled to the audio buffer, the processor operatively coupled to the data buffer, wherein the processor is configured to execute the instructions to perform operations comprising: receiving the microphone signal; sending a portion of the microphone signal to the audio buffer; analyzing the audio buffer for detecting a sonic signature; notifying a user when the sonic signature is detected; sending a modified microphone signal to the data buffer replacing or adding to previous data stored in the data buffer; and sending a portion of the data stored in the data buffer, spanning a time period, to the speaker in response to a user request, wherein the user request is one of the sonic signature that is a voice command or a manual input from the user interface.

64. The Accused Product is an automotive acoustic management system. The system is implemented in the cockpit of a vehicle. The cockpit functions as a user interface, a processor, memory to store instructions, and an audio buffer. HARMAN External Microphones are placed on the exterior of the vehicle and used to capture ambient acoustic sound external to the vehicle, for example engine noise, road noise, and speech. Internal microphones can also be used to capture internal ambient acoustic sound within the cabin of the vehicle as microphones configured to measure ambient sound and generate a microphone signal. Upon information and belief, the captured ambient acoustic sound is communicated to the cockpit of the vehicle. Within the cockpit processor, a portion of the microphone signal is placed in an audio buffer and analyzed for the presence of a sonic signature, such as a voice command from “[e]xternal speech recognition” or

"verbal interaction." Then, data stored in the audio buffer can be sent to the car speakers upon a user request.

Harnessing Sound to Enhance Automotive Experiences

Innovation in today's automotive landscape is all about enabling aspirational consumer experiences at the speed of demand. At HARMAN, we are at the forefront of this bold new era with a host of cutting-edge solutions, like the External Microphone.

With its robust design and easy vehicle integration capabilities, this game-changing acoustic sensor is raising the bar for verbal interaction and situational awareness. External speech recognition, enhanced acoustic detection, increased awareness of approaching vehicles – it's all made possible with the HARMAN External Microphone.

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Source: https://car.harman.com/solutions/car-audio

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66. Defendant's direct and indirect infringement of the '587 Patent has damaged and will continue to damage Plaintiff.

67. Plaintiff is entitled to recover damages adequate to compensate it for Defendant's direct and indirect infringement.

68. After receiving actual notice of the ’587 Patent, Defendant proceeded to make, use, test, sell, and/or offer to sell in this District and elsewhere in the United States, and import into this District and elsewhere in the United States, the Accused Product.

69. On information and belief, Defendant engaged in such activities despite an objectively high likelihood that its actions constituted infringement and inducement of infringement of the ’587 Patent. Defendant knew and should have known that its actions would cause direct and induced infringement of the ’587 Patent, and on information and belief, Defendant has monitored the substantial prior art submissions made prior to issuance of the ’587 patent.

70. Defendant has willfully infringed and continues to willfully infringe the ’587 Patent.

DEMAND FOR JURY TRIAL

71. Pursuant to Fed. R. Civ. P. 38, Plaintiff hereby respectfully requests trial by jury on all claims and issues so triable.

REQUEST FOR RELIEF

72. WHEREFORE, Plaintiff respectfully requests the following relief:

a) The entry of judgment, in favor of Plaintiff and against Defendant, that the Asserted Patents are valid and enforceable;

b) The entry of judgment, in favor of Plaintiff and against Defendant, that Defendant has infringed, directly and indirectly, either literally or under the Doctrine of Equivalents, one or more claims of the ’620 Patent;

c) The entry of judgment, in favor of Plaintiff and against Defendant, that the Defendant’s infringement of the ’620 Patent has been willful, and that the Defendant’s continued infringement of the ‘620 Patent is willful;

d) The entry of judgment, in favor of Plaintiff and against Defendant, that Defendant has infringed, directly and indirectly, either literally or under the Doctrine of Equivalents, one or more claims of the ’329 Patent;

e) The entry of judgment, in favor of Plaintiff and against Defendant, that the Defendant’s infringement of the ’329 Patent has been willful, and that the Defendant’s continued infringement of the ’329 Patent is willful;

f) The entry of judgment, in favor of Plaintiff and against Defendant, that Defendant has infringed, directly and indirectly, either literally or under the Doctrine of Equivalents, one or more claims of the ’587 Patent;

g) The entry of judgment, in favor of Plaintiff and against Defendant, that the Defendant’s infringement of the ’587 Patent has been willful, and that the Defendant’s continued infringement of the ’587 Patent is willful;

h) The entry of judgment, in favor of Plaintiff and against Defendant, awarding Plaintiff all appropriate damages under 35 U.S.C. § 284 for Defendant’s past infringement, and any continuing or future infringement of the Asserted Patents, including pre- and post-judgment interest, costs, and disbursements as justified under 35 U.S.C. § 284 and, if necessary, an accounting, and further:

i. That Plaintiff be awarded enhanced damages by reason of the Defendant’s willful infringement of the ’620 Patent;

ii. That Plaintiff be awarded enhanced damages by reason of the Defendant’s willful infringement of the ’329 Patent;

iii. That Plaintiff be awarded enhanced damages by reason of the Defendant’s willful infringement of the ’587 Patent;

iv. That this case be declared exceptional within the meaning of 35 U.S.C. § 285 and that Plaintiff be awarded its reasonable attorneys' fees against the Defendant incurred in prosecuting this action; and

v. That Plaintiff be awarded its costs and expenses incurred in prosecuting this action.

i) The entry of a permanent injunction, enjoining Defendant, its subsidiaries, and any person or entity acting in concert with Defendant from making, using, selling, offering to sell, or importing any products that infringe the Asserted Patents, and any other injunctive relief the Court deems just and equitable; and

j) The entry of judgment, in favor of Plaintiff and against Defendant, that awarding Plaintiff such further relief at law or in equity as the Court deems just and proper.

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Dated: July 25, 2023

EXHIBIT A

US008319620B2

(12) **United States Patent**
Usher et al.

(10) **Patent No.: US 8,319,620 B2**
(45) **Date of Patent: Nov. 27, 2012**

(54) **AMBIENT SITUATION AWARENESS SYSTEM AND METHOD FOR VEHICLES**

(75) Inventors: **John Usher**, Beer (GB); **John P Keady**, Boca Raton, FL (US)

(73) Assignee: **Personics Holdings Inc.**, Boca Raton, FL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 716 days.

(21) Appl. No.: **12/487,639**

(22) Filed: **Jun. 18, 2009**

(65) **Prior Publication Data**

US 2010/0033313 A1 Feb. 11, 2010

Related U.S. Application Data

(60) Provisional application No. 61/074,096, filed on Jun. 19, 2008.

(51) **Int. Cl.**

B60Q 1/00	(2006.01)
B60R 25/10	(2006.01)
H04B 1/00	(2006.01)
H04R 3/00	(2006.01)

(52) **U.S. Cl.** **340/438**; 340/426.26; 340/425.5; 340/566; 367/199; 381/56; 381/86; 381/122

(58) **Field of Classification Search** 340/438, 340/426.26

See application file for complete search history.

(56) **References Cited**

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U.S. Appl. No. 12/035,873, filed Feb. 22, 2008.
U.S. Appl. No. 11/966,457, filed Dec. 28, 2007.

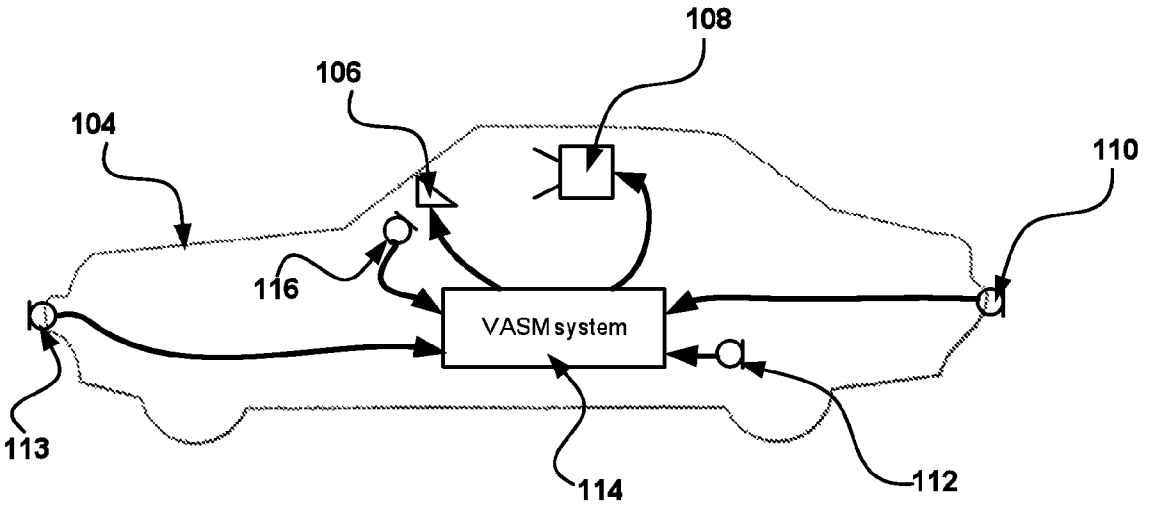
* cited by examiner

Primary Examiner — Donnie Crosland
(74) *Attorney, Agent, or Firm* — RatnerPrestia

(57) **ABSTRACT**

Methods and devices for situation awareness facilitation for a vehicle driver are provided. A method includes receiving a first acoustic signal from outside a vehicle that the driver is in and converting the first acoustic signal into a first acoustic electronic signal; sending the first acoustic electronic signal to a processor; matching the first acoustic electronic signal by the processor to stored reference electronic signals; and sending an acoustic message associated with a matched reference electronic signal to a speaker in the cab of the vehicle.

15 Claims, 5 Drawing Sheets



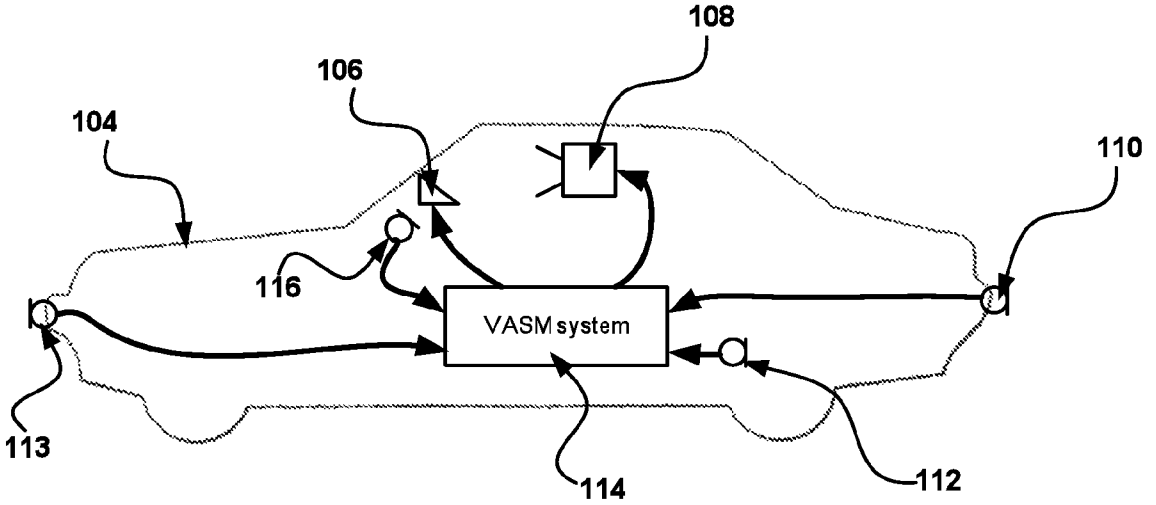


FIG. 1

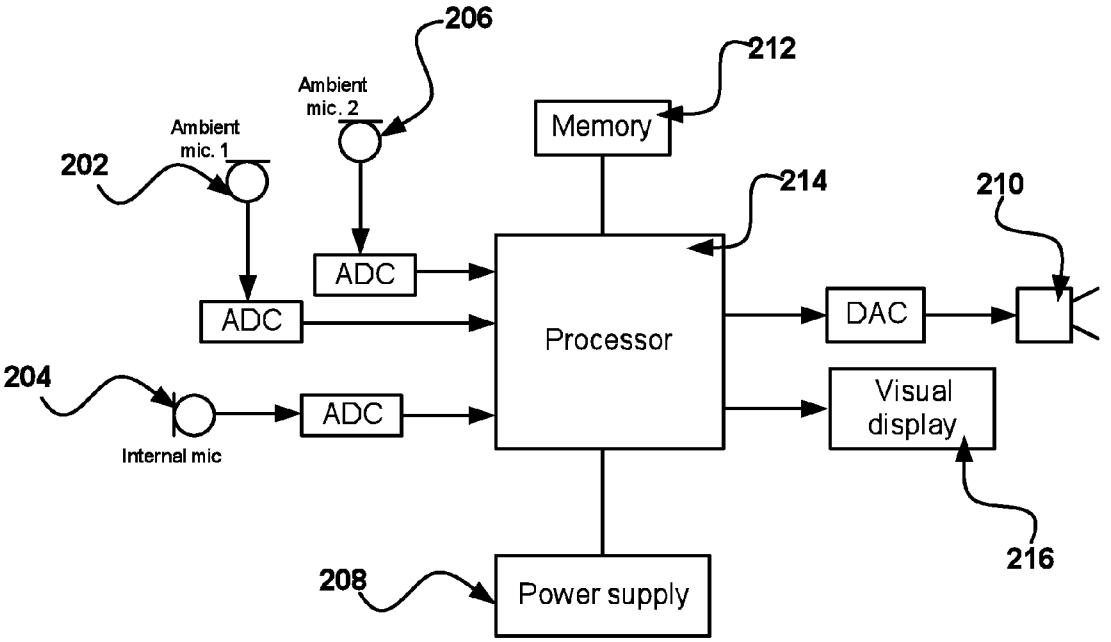

206
212
Ambient mic. 2
Memory
Ambient mic. 1
202
214
210
ADC
ADC
Processor
DAC
204
ADC
Visual display
Internal mic
216
208
Power supply

FIG. 2

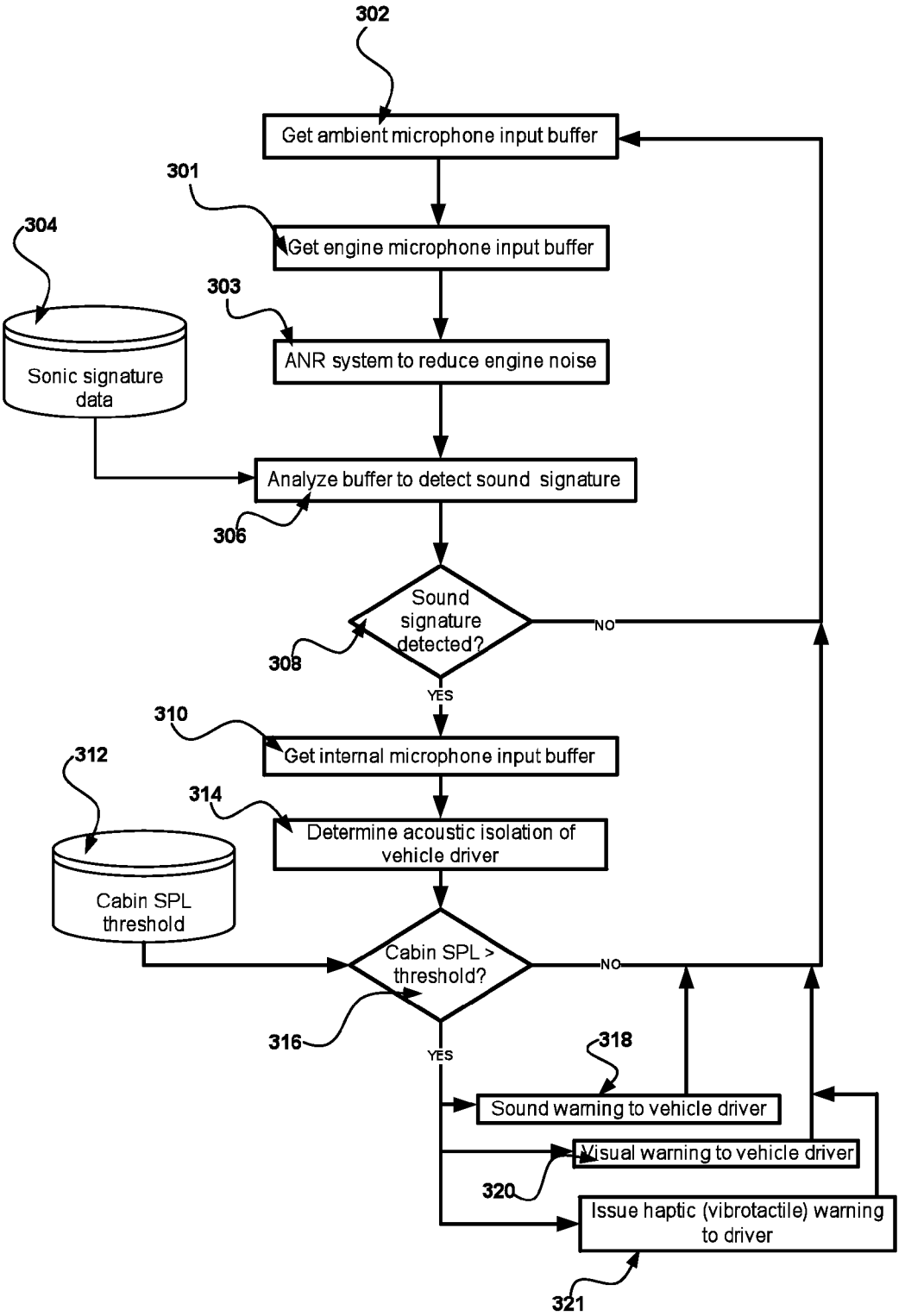

302
Get ambient microphone input buffer
301
Get engine microphone input buffer
304
Sonic signature data
303
ANR system to reduce engine noise
Analyze buffer to detect sound signature
306
Sound signature detected?
308
NO
YES
310
Get internal microphone input buffer
312
Cabin SPL threshold
314
Determine acoustic isolation of vehicle driver
Cabin SPL > threshold?
316
NO
YES
318
Sound warning to vehicle driver
Visual warning to vehicle driver
320
Issue haptic (vibrotactile) warning to driver
321

FIG. 3

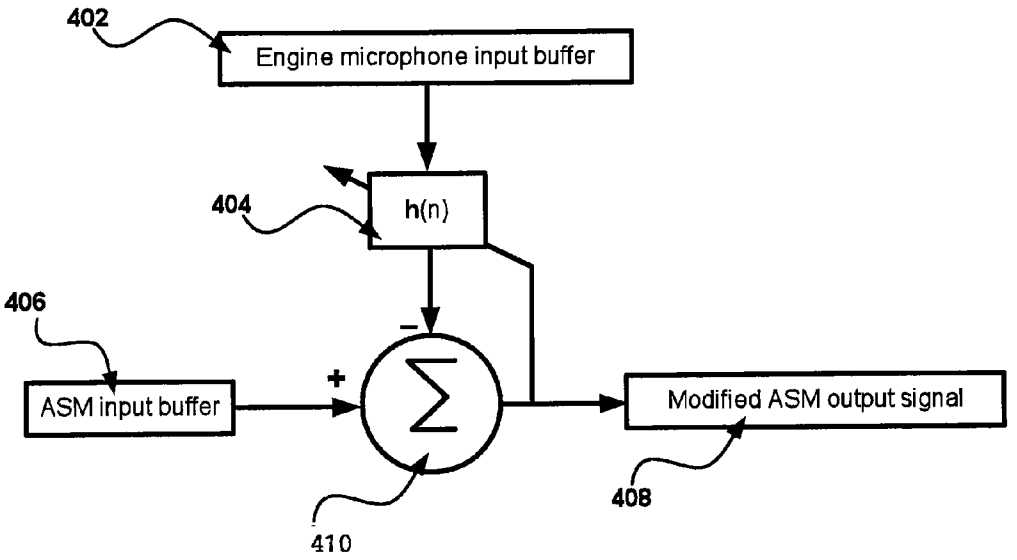

402
Engine microphone input buffer
404
h(n)
406
ASM input buffer
+
−
Σ
Modified ASM output signal
408
410

FIG. 4

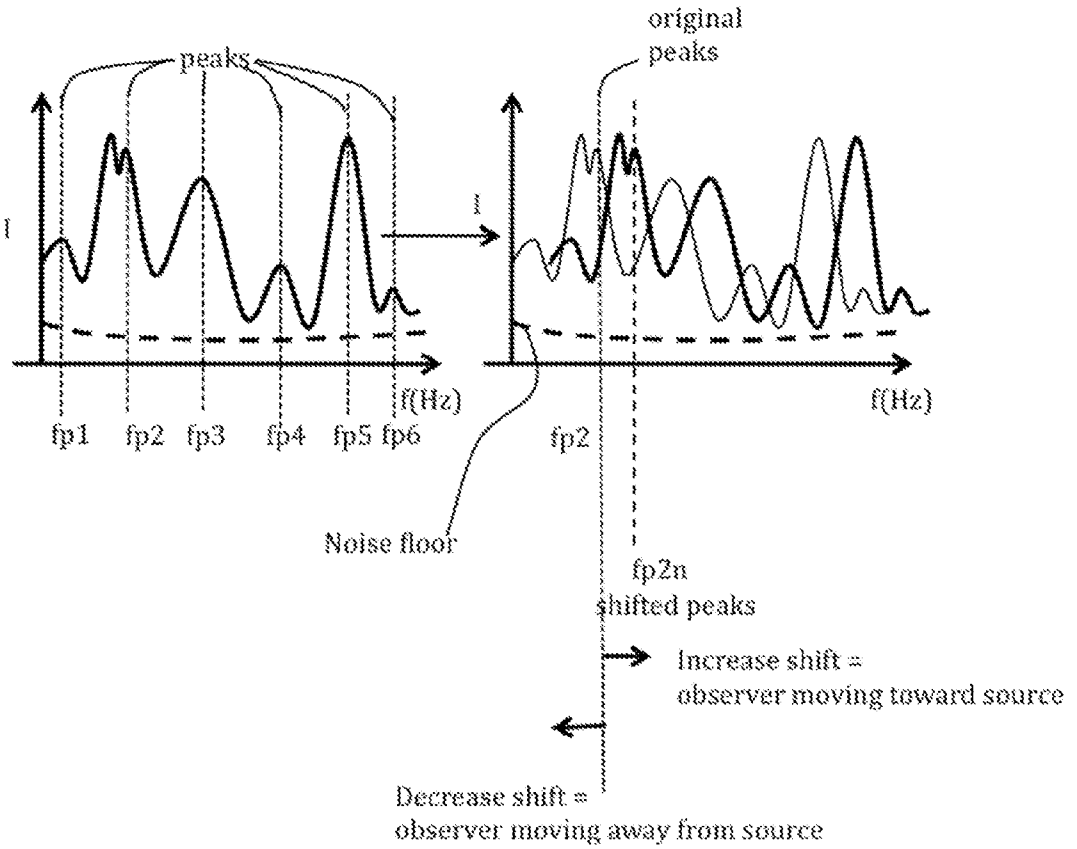

peaks
I
f(Hz)
fp1
fp2
fp3
fp4
fp5
fp6
original
peaks
I
f(Hz)
fp2
Noise floor
fp2n
shifted peaks
Increase shift =
observer moving toward source
Decrease shift =
observer moving away from source

FIG. 5

AMBIENT SITUATION AWARENESS SYSTEM AND METHOD FOR VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. provisional patent application No. 61/074,096 filed 19 Jun. 2008. The disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

The present invention relates to devices and methods for vehicle situation awareness.

BACKGROUND OF THE INVENTION

Detection of sirens is discussed by a number of works.

U.S. Pat. No. 5,710,555 describes: "A siren detection system [controlling] the lights at an intersection to direct traffic [to] permit an emergency vehicle to travel through the intersection unimpeded. The system determines the frequency of the sound emanating from a siren carried by the emergency vehicle by counting pulses that indicate the frequency of the sound, by determining the elapsed time necessary to count a selected number of pulses, and by utilizing the elapsed time and number of pulses counted to determine the frequency of sound emitted by the siren."

A similar idea is presented in U.S. Pat. No. 6,980,125:

"A warning light system for a traffic intersection for alerting pedestrians and operators of passenger vehicles to the approach of an emergency vehicle. The warning light system is activated only by sounds in the range of frequencies which are emitted by the siren of an emergency vehicle. The warning light system has a warning light assembly having a control unit, and also has an audio sensor unit. The warning light assembly has a blue light and a white light, which flash alternately and repeatedly, after receipt of an audio signal by the audio sensor unit from the siren of an emergency vehicle, and processing of that signal by the control unit. The lights of the warning light assembly continuously flash until the sound emitted from the siren is no longer detectable by the audio sensor."

US patent application US 2005/0074131 A1 describes: "A sound processing system for use in an automotive vehicle of the type which includes at least one door and at least one door-lock comprises at least one sound sensor coupled to the vehicle for receiving a sound external to the vehicle, an alert generator for notifying an occupant of the vehicle when the external sound is an emergency signal, and a door control module coupled to at least one door-lock for unlocking at least one door."

The above art (except US 2005/0074131 A1) does not suggest how to alert a driver of a vehicle of the presence of an approaching siren (e.g. from an emergency vehicle); or how to alert a driver of a vehicle of the presence of a different sound generated in the vicinity of the car, such as a car horn, or any sound which could be classified with more general parameters, such as a sudden onset sound (or "acute sound").

This problem is particularly pertinent when drivers are listening to loud music or communications systems such as CB radios, or when operating their vehicle's ventilation system at high fan speeds, any of which may mask any warning sounds in the ambient environment.

US patent application US 2005/0074131 does not teach a method to determine the sound level within a vehicle, nor

determine the degree of acoustic isolation of the internal vehicle cabin. The present invention adds this functionality so that the driver alert can be modified to maximize detection and intelligibility of the warning alert. Furthermore, the present invention enables the location of an external sound source (e.g. siren) to be determined by detecting the strength of the detected sound in different ambient sound microphones around the vehicle.

SUMMARY OF THE INVENTION

At least one exemplary embodiment is directed to a method to detect malfunction of a vehicle subsystem or vehicle accessory (such as a malfunctioning brake caliper on a passenger vehicle or a malfunctioning rotor blade(s) on a combine-harvester). Furthermore, the related art does not teach a method or system to detect a variety of sound characteristics. The system of the present invention is directed to detecting at least one of the following examples of "signature sounds": sirens, car horns, "impulsive" sound with a rapid onset time (or "onset rate" e.g. change in sound pressure level of greater than approximately 10 dB per second), sound with a rapid offset stopping time (e.g. greater than approximately 10 dB per second), and sound with a sudden change in tonal quality (e.g. a shift in the spectral kurtosis of a sound, or sudden change in frequency and level of spectral centroid).

At least one exemplary embodiment is directed to a vehicle situation awareness device comprising: a notification device, where the notification device is configured to emit a first signal; a microphone, where the microphone is configured to measure a second signal, where the second signal is a measurement of at least a first portion of an ambient acoustic signal; and a processor, where at least one sonic signature is identified from at least a second portion of the second signal, and where when the at least one sonic signature is identified an emit signal is sent to the notification device to emit the first signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. **1** illustrates a vehicle ambient sound monitoring system (VASM) in accordance with at least one exemplary embodiment;

FIG. **2** illustrates an example of at least one VASM in accordance with at least one exemplary embodiment;

FIG. **3** illustrates at least one exemplary embodiment of the present VASM invention depicting a method to inform the vehicle driver of a detected sound signature in the ambient environment;

FIG. **4** illustrates an exemplary embodiment of the Active Noise Reduction (ANR) system; and

FIG. **5** illustrates the spectrum Doppler shift of an identified sonic signature spectrum.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS OF THE PRESENT INVENTION

The following description of exemplary embodiment(s) is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Processes, techniques, apparatus, and materials as known by one of ordinary skill in the art may not be discussed in detail but are intended to be part of the enabling description

where appropriate. For example specific materials may not be listed for achieving each of the targeted properties discussed, however one of ordinary skill would be able, without undo experimentation, to determine the materials needed given the enabling disclosure herein.

Additionally, exemplary embodiments can be used with digital and non-digital acoustic systems. Additionally various receivers and microphones can be used, for example MEMs transducers, diaphragm transducers, for example Knowles' FG and EG series transducers.

The following description of exemplary embodiment(s) is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Exemplary embodiments are directed to or can be operatively used on various vehicles, such as tractors; bulldozers; automobiles; buses; aircraft; and also motorcycle helmets.

Processes, techniques, apparatus, and materials as known by one of ordinary skill in the art may not be discussed in detail but are intended to be part of the enabling description where appropriate. For example specific computer code may not be listed for achieving each of the steps discussed, however one of ordinary skill would be able, without undo experimentation, to write such code given the enabling disclosure herein. Such code is intended to fall within the scope of at least one exemplary embodiment.

Notice that similar reference numerals and letters refer to similar items in the following figures, and thus once an item is defined in one figure, it may not be discussed or further defined in the following figures.

Note that various sonic signature identification methods can be used for example application Ser. Nos. 12/035,873 and 11/966,457, the disclosures of which are incorporated herein by reference in their entirety.

EXEMPLARY EMBODIMENTS

FIG. **1** illustrates an exemplary embodiment of the Vehicle ambient sound monitoring system (VASM). In this configuration, at least one Ambient Sound Microphone (ASM) **110** **112**, **113** are mounted on the exterior of the vehicle **104** and configured to detect sound around the vehicle **104**. These microphones can be highly directional, using passive acoustic beam-forming technology (such as "shot-gun" microphones, familiar to those skilled in the art), or alternatively may use active beam-forming techniques using an array of at least three microphones. This enables the direction (or bearing) of a sound source to be determined. The microphones can be transducer microphones such as Knowles MR series weather proof microphones, WP series, TP series, FB series, and other series microphones or other acoustic energy pickup devices.

At least one exemplary embodiment of the VASM system **114** comprises the hardware components depicted in FIG. **2**. The VASM detects "signature sounds" with the ASMs **110**, **112** (e.g., **202**, **206**). Examples of "signature sounds" are: —sirens; —car horns; —"impulsive" sound with a rapid onset time (or "onset rate" e.g. change in sound pressure level of greater than approximately 10 dB per second); —sound with a rapid offset stopping time (e.g. greater than 10 dB per second); —sound with a sudden change in tonal quality (e.g. a shift in the spectral kurtosis of a sound, as described in FIG. **4**); —sound with a rapid slewing (escalation/de-escalation) in frequency, as exemplified by the wail setting on U.S. sirens; —motorcycle engines.

The VASM compares at least one predetermined feature with at least one measured feature of at least one ASM signal. When the measured ASM sound characteristic substantially matches (e.g., within +/−5% of the FFT spectrum with a time increment dt) the at least one predetermined feature, for example the VASM system can notify the vehicle driver using at least one of the following non-limiting exemplary alerts: —a visual alert using visual display **106**, e.g. a flashing light or text message, which in one exemplary embodiment is projected on to the windscreen of the vehicle, on to a combiner glass on the upper dashboard, or on to the visor panel of a helmet (i.e., a "head-up" display; —a haptic alert (tactile display) which imparts a distinct, readily detectable high-frequency vibration to the body of the driver, via one or more vibro-tactile transducers mounted in the seat pan or back, within the steering wheel rim, on the foot pedals, or in the internal cushioning or chin strap of a motorcycle helmet; —a sound alert (i.e. "auditory display") using an internal loudspeaker **108** to generate a sound in the vehicle cabin; or in another exemplary embodiment, the sound alert may be reproduced to the vehicle driver using an earphone device. In one exemplary embodiment, the alert is a reproduction of the ASM microphone signal that is used to detect the signature sound. In another embodiment, the auditory alert is a pre-recorded voice or non-voice message.

In one exemplary embodiment of the present invention, at least two loudspeakers are used, each being positioned to bias its output to one ear or the other, and the level and/or phasing of the alert signal that is sent to each loudspeaker is automatically adjusted by the VASM to facilitate the localization of the sound source in the ambient environment using spatial sound cues (in one exemplary embodiment, the alert signal may also have a different relative phase in each loudspeaker).

The internal microphone sensor **116** is configured to detect the sound pressure level (SPL) in decibels and (optionally) the sound spectral profile within the vehicle cabin (or helmet). If the internal cabin SPL is equal to or greater than a predetermined threshold (which in one exemplary embodiment is approximately 80 dB), then the reproduction SPL level of the sound alert, i.e., the "signal," is increased so that it is reproduced at a level greater than the interior cabin SPL, i.e., the "noise," by a predetermined signal-to-noise ratio to insure reliable and rapid detection by the driver. It will be obvious to one having ordinary skill in the art that the signal-to-noise ratio can be adjusted to accommodate particular vehicles and particular hearing abilities of individual drivers.

In yet another exemplary embodiment of the invention, the degree of acoustic isolation of the internal vehicle cabin (or helmet) is determined using at least one internal microphone **116** and at least one ambient microphone **112**. The acoustic isolation is determined by analyzing the electronic cross correlation, or alternatively the coherence, between the at least one internal microphone and the at least one ambient microphone. If the absolute correlation or coherence is less than a predetermined threshold, then the cabin is determined to be acoustically isolated. Other methods to determined the degree of acoustic isolation of the interior vehicle cabin may also be used, such as detecting the status of the vehicle windows, doors, and ventilation system, and comparing this status with a predetermined database, e.g. if all windows, doors, and ventilation vents are closed, then the acoustic isolation status may be set to "high", or a corresponding numerical value (e.g. 20 dB).

FIG. **2** depicts an exemplary hardware assembly for the present VASM invention. The assembly comprises the following components: at least one ASM **202**, **206**, a signal of which is converted to a digital signal via the Analog to Digital Converter (ADC) units; at least one internal microphone **204** to detect sound on the inside of the vehicle (or motorcycle helmet); a signal processing unit **214**; computer readable memory **212**; power supply **208**; visual display unit **216**; and

at least one internal loudspeaker unit **210**, which receives an analog signal that has been converted via a Digital to Analog Converter (DAC).

FIG. **3** depicts an exemplary embodiment of the present VASM invention depicting a method to inform the vehicle driver of a detected sound signature in the ambient environment.

The method comprises the following steps: accumulating an input ASM buffer of digital audio samples representing the signal from at least one ASM, step **302**. At step **303**, OPTIONALLY reducing the level of the vehicle engine noise; wind-noise (i.e. air turbulence generated by the car and microphone); chassis-propagation noise (noise generated by tire friction and suspension emissions) in the ASM using an Active Noise Reduction (ANR) system. Step **303** is described in FIG. **4**. In this example embodiment, the ANR subtracts a filtered and time-shifted reference signal (which in one exemplary embodiment, is a signal from a microphone near the vehicle engine, at step **301**), from the ASM signal (step **302**). Such ANR systems are familiar to those skilled in the art. In one exemplary embodiment, the filter is an adaptive filter updated according to the Least Means Square (LMS) algorithm. The method includes analyzing the input ASM buffer to generate a set of ASM signal characteristics (step **306**), and comparing the set of ASM signal characteristics with a predetermined set of characteristics **304** to detect a sound signature if the sets of signal characteristics are substantially similar. The method also includes determining if a sound signature is detected with a logic unit at step **308**, and if it is not, the process is repeated at step **302**. The method of detection can use the GMM approach, familiar to those skilled in the art. Alternatively, the method of detection can use the rate of change of the ASM (or modified ASM) signal envelope to detect sudden onsets or offsets. If a sound signature is detected at step **308**, then the SPL in the interior cabin of the vehicle is determined at step **314** using an internal microphone input buffer at step **310**. If, at step **316**, the SPL of the interior cabin of the vehicle is greater than a predetermined threshold **312**, AND a sound signature has been detected, then at least one of three alerts are issued: a.) An audible warning **318**; b.) A visual warning **320**; and c.) A haptic (vibrotactile) warning **321**. The vibrotactile mode can be very effective in conveying the locale of a target signal if multiple vibrotactors are used, e.g., one under the front of the thigh in the seat pan cushion (signaling an approach from front), two in the seat back cushion (approach from the back; left right directionality, etc.). Furthermore, vibrotactors provide a great opportunity for conveying a speed of approach of the oncoming siren, with the use of a single transducer, by increasing the frequency and/or amplitude of the vibration to coincide with the increasing speed or "closing of the gap" of an approaching emergency vehicle.

An audible warning can be presented to the driver using at least one loudspeaker in the vehicle cabin, or using earphone devices within a helmet. The direction of the ambient sound, which triggered the warning can be determined using an array of at least two ASMs mounted on the vehicle, and using active beam-forming techniques, familiar to those skilled in the art, to determine the dominant direction of the sound source. Alternatively, as already mentioned, highly directional ASM microphones (such as "shot-gun" microphones) can be used, and the corresponding direction of the ASM that detected the sound signature with the highest degree of certainty can be used to ascertain the source direction.

Doppler sound cues can be used to determine a speed and a bearing of approaching vehicles. The Doppler shift rate (in Hz/second) can be estimated by the rate of change of a strong spectral feature. Once a sonic signature has been identified, key frequency dependencies can be used to obtain a shift in the characteristic spectrum. For example FIG. **5** illustrates a stored frequency spectrum of a particular sonic signature in a chosen time frame (e.g., 100 msec) with peak frequencies fp**1** to fp**6** for a stationary source (vs=0) and a stationary vehicle (vo=0). A particular sonic signature can have the key frequency spectrum shifted due to motion of the sound source (vs < >0) and/or due to motion of the vehicle (vo< >0). A frequency shift can be described as

fp**2***n*=fp**2**((v+/−vo)/(v−/+vs)), where the upper sign is used if the source/vehicle move toward each other and the lower sign applies if they are moving apart. If the vehicle motion is isolated using motion devices (e.g., accelerometers, GPS) then vo can be measured by these devices (e.g., vox, voy, voz, in the respective three directions), and if v (speed of sound) is known, then vs can be determined after determining the frequency shift from the spectrums.

When the vehicle is parked or reversing, the ASM signals are reproduced to the internal cabin via the cabin loudspeakers. In one exemplary embodiment, the reproduced ASM signals are first processed with the ANR system described (to remove masking noise) as in FIG. **4**, thus increasing the situation awareness of the vehicle occupants for local sound sources, such as a child behind the car. In one exemplary configuration, when the car is reversing only the rear ASM signals (e.g. those on the rear bumper) are reproduced, and the spatial cues of the ambient environment can be preserved within the vehicle cabin by reproducing the rear-left ASM signal with the rear-left loudspeaker in the vehicle, and the rear-right ASM signal with the rear-right loudspeaker.

FIG. **4** describes an exemplary embodiment of the Active Noise Reduction (ANR) system **303**. In one exemplary embodiment, the engine microphone input buffer **402** is a first input signal from a microphone close to or directly coupled with the vehicle engine. In another exemplary embodiment, this input signal **402** is a signal that has been stored on computer readable memory or automatically generated. The first input signal **402** is filtered by a frequency dependant adaptive filter **404**, with filter coefficients h(n), to produced a filtered signal, where:

$$h(n)=[h_0, h_1 \ldots h_n].$$

The filtered signal is then subtracted from the ASM input buffer **406** via subtractor **410**, which in one exemplary embodiment is the signal from one ASM microphone located on the bumper of the vehicle. The resulting modified ASM output signal **408** is then used for the sound signature identification system. The modified ASM output signal **408** is also used to update the adaptive filter coefficients h(n), which in one exemplary embodiment is updated using the LMS algorithm:

$$\hat{h}(n+1)=\hat{h}(n)+\mu x(n)e^*(n)$$

Where x(n) is a vector of the samples of the engine microphone input buffer **402**; e(n) is a single output sample of the modified ASM output signal **408**; and μ is a step size update coefficient.

At least one exemplary embodiment is directed to localization of the sound source, using either the visual indicator or a multi-channel loudspeaker audio system in the vehicle. Localization can be ascertained in terms of an azimuthal bearing of an ambient sound source. Furthermore, a velocity of an ambient sound source can be reported to the user with Doppler cues.

The active pass-through of the ASM signal to internal loudspeakers, via the ANR system may be used, to increase

situational awareness of the vehicle occupants to local sound sources, such as a human who may be obscured from view behind the vehicle.

An ANR system may be used to reduce the engine, chassis, wind or other noise in the ASM signals.

None of the cited art teach a method to detect malfunction of a vehicle engine or vehicle accessory (such as a malfunctioning rotor blade(s) on a combine-harvester).

Furthermore, the related art does not teach a method or system to detect a variety of sound characteristics. The system of the present invention is directed to detecting at least one of the following examples of "signature sounds": —sirens; —car horns; —"impulsive" sound with a rapid onset time (or "onset rate" e.g. change in sound pressure level of greater than approximately 10 dB per second); —sound with a rapid offset stopping time (e.g. greater than 10 dB per second); —sound with a sudden change in tonal quality (e.g. a shift in the spectral kurtosis of a sound, as described in FIG. **4**); —sound with a rapid slewing (escalation/de-escalation) in frequency, as exemplified by the wail setting on U.S. sirens; —motorcycle engines. The method of detection can use the GMM approach, familiar to those skilled in the art. Alternatively, the method of detection can use the rate of change of the ASM (or modified ASM) signal envelope to detect sudden onsets or offsets. In addition, in at least one exemplary embodiment the method of alerting the vehicle user is modified by the user's ambient sound level (i.e. the sound level of the internal vehicle cabin, or the sound level within the helmet).

At least one exemplary embodiment is directed to a vehicle situation awareness device comprising: a notification device, where the notification device is configured to emit a first signal; a microphone, where the microphone is configured to measure a second signal, where the second signal is a measurement of at least a first portion of an ambient acoustic signal; and a processor, where at least one sonic signature is identified from at least a second portion of the second signal, and where when the at least one sonic signature is identified an emit signal is sent to the notification device to emit the first signal.

The notification device can be a speaker (receiver) in the vehicle passenger compartment. For example if a sonic signature is identified and information is available to determine whether it is coming toward the vehicle, an audio signal can be emitted from the speaker (receiver) identifying the source and that the source is approaching the vehicle and from which direction and at which rate. Additionally the notification device can be a display (e.g., lights, a heads up display, video). For example if an ambulance is identified a visual display in the instrument panel can identify the location and whether it is approaching (e.g., light for location about a car outline, and red for approaching and green for moving away).

In at least one exemplary embodiment the notification device is inside the vehicle. For example a speaker in the vehicle cabin, as well as outside (external speaker). In at least one exemplary embodiment the first signal can be an electronic signal sent to the notification device, which in turn then emits an acoustic signal, thus either the electronic signal or acoustic signal can be referred to as an audio signal.

At least one exemplary embodiment monitors the vehicle's systems (e.g., engines, brakes, window breakage). A microphone can be placed strategically where an acoustic signal can be sampled for sonic signatures, which identify vehicle performance. For example a normal operating engine can be acoustically signatured (sonic signature model trained to identify a correctly operating engine) then monitored to look for abnormalities in the engine performance. For example a microphone, where the microphone is configured to measure a second signal (e.g., acoustic signal in the engine compartment) where the second signal is a measurement of at least a first portion of a vehicle equipment signal (e.g., the engine acoustic signal). A processor can be used to analyze at least a second portion (e.g., time segment) of the second signal, to identify at least one sonic signature (e.g., non normal engine performance). For example the system can continuously sample for normal performance and upon the lack of detection over a predetermined amount of time (e.g., 1 minute), a warning signal (e.g., emit signal) can be sent to the notification device.

Note that in at least one exemplary embodiment the notification device can also be a video display, for example a heads up display, an LCD display, an outline of the vehicle with lights around the outline so as to identify detection location, colored labeled lights to identify as well as other visual notification systems as known by one of ordinary skill in the art of notification.

At least one exemplary embodiment can use a second processor that takes an emit signal (e.g., engine error signal) and send a control signal to the vehicle control system (e.g., engine processor) to modify system operation (e.g., vary fuel/air mixture). Many aspects of the vehicle can be controlled in response to an emit signal, for example shifting gears, decreasing power usage, sending a remote signal, operating the windshield wiper, and changing the headlight illumination.

At least one exemplary embodiment can include a microphone, where the microphone is configured to measure an interior vehicle acoustic signal or an external vehicle acoustic signal where a portion of the measured acoustic signal is used to identify sonic signatures and depending upon the sonic signature an action is taken (e.g., abnormal tire sound, an action to send a warning to the driver) or not taken (e.g., sonic signature is a normal tire operation, then no action is taken).

In at least one exemplary embodiment the sonic signature is a voice command. For example a user can store his command "open", where if the sonic signature "open" is identified a command is sent to a processor to open the vehicle doors. Similar commands such as "open gas tank", "open door", "start", "alarm", and other such commands can be used to control the vehicle. At least one further exemplary embodiment to modify vehicle operation includes one of at least opening a door, opening the trunk, opening the gas tank access panel, opening the hood, turning on the headlights, turning on an audio alarm, and beginning audio recording.

At least one exemplary embodiment is directed to a method of situation awareness facilitation for a vehicle driver comprising: receiving a first acoustic signal from outside a vehicle that the driver is in and converting the first acoustic signal into a first acoustic electronic signal; sending the first acoustic electronic signal to a processor; matching the first acoustic electronic signal by the processor to stored reference electronic signals; and sending an acoustic message associated with a matched reference electronic signal to a speaker in the cabin of the vehicle.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all modifications, equivalent structures and functions of the relevant exemplary embodiments. For example, if words such as "orthogonal", "perpendicular" are used the intended meaning is "substantially orthogonal" and "substantially perpendicular" respectively. Additionally although specific numbers

may be quoted in the claims, it is intended that a number close to the one stated is also within the intended scope, i.e. any stated number (e.g., 20 mils) should be interpreted to be "about" the value of the stated number (e.g., about 20 mils).

Thus, the description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the exemplary embodiments of the present invention. Such variations are not to be regarded as a departure from the spirit and scope of the present invention.

What is claimed is:

1. A vehicle situation awareness device for a vehicle comprising:

a notification device in the vehicle configured to emit an audio signal;

an internal microphone configured to measure an internal acoustic signal in the vehicle;

an ambient microphone configured to measure an ambient acoustic signal external to the vehicle; and

a processor configured to:

determine an internal sound pressure level (SPL) in the vehicle based on the internal acoustic signal,

identify at least one sonic signature from the ambient acoustic signal, and

when the at least one sonic signature is identified, determine whether to send an emit signal to the notification device to emit the audio signal based on the internal SPL.

2. The awareness device according to claim **1**, where the notification device includes a receiver.

3. The awareness device according to claim **1**, where the notification device further includes a video display.

4. The awareness device according to claim **1**, where the audio signal includes at least one of the ambient acoustic signal, a voice message or a non-voice message.

5. The awareness device according to claim **1**, where the processor adjusts a reproduction SPL of the audio signal based on the internal SPL.

6. A vehicle situation awareness device for a vehicle comprising:

a notification device in the vehicle configured to emit an alert signal including an audio signal;

an internal microphone configured to measure an internal acoustic signal in the vehicle;

an external microphone configured to measure a vehicle equipment signal; and

a processor configured to:

determine an internal sound pressure level (SPL) in the vehicle based on the internal acoustic signal,

identify at least one sonic signature from the vehicle equipment signal, and

when the at least one sonic signature is identified, determine whether to send an emit signal to the notification device to emit the audio signal based on the internal SPL.

7. The awareness device according to claim **6**, where the notification device includes a receiver.

8. The awareness device according to claim **6**, where the notification device includes a video display.

9. The awareness device according to claim **6**, where the alert signal is an input to a second processor, the alert signal used by the second processor to affect an operation of the vehicle.

10. The awareness device according to claim **9**, where the operation is at least one of shifting gears, decreasing power usage, sending a remote signal, operating a windshield wiper, and changing a headlight illumination.

11. A vehicle situation awareness device for a vehicle comprising:

a notification device in the vehicle configured to emit an alert signal to a first processor, the first processor used to modify an operation of the vehicle responsive to the alert signal;

an internal microphone configured to measure an interior vehicle acoustic signal in the vehicle;

an external microphone configured to measure an external vehicle acoustic signal; and

a second processor, configured to:

determine an interior sound pressure level (SPL) in the vehicle based on the interior vehicle acoustic signal;

identify at least one sonic signature from at least one of the interior vehicle acoustic signal or the external vehicle acoustic signal, and

when the at least one sonic signature is identified, determine whether to send an emit signal to the notification device to emit the alert signal based on the interior SPL.

12. The awareness device according to claim **11**, where the at least one sonic signature is a vocal command.

13. The awareness device according to claim **12**, where the alert signal uniquely corresponds to the voice command.

14. The awareness device according to claim **11**, where the operation includes one of at least opening a door, opening a trunk, opening a gas tank access panel, opening the hood, turning on headlights, turning on an audio alarm, and beginning an audio recording.

15. A method of situation awareness facilitation for a vehicle driver of a vehicle, the method comprising:

receiving an internal acoustic signal from inside the vehicle and converting the internal acoustic signal to an internal acoustic electronic signal;

receiving an ambient acoustic signal from outside the vehicle and converting the ambient acoustic signal into an ambient acoustic electronic signal;

determining, by a processor, an internal sound pressure level (SPL) in the vehicle based on the internal acoustic electronic signal;

matching, by the processor, the ambient acoustic electronic signal to one or more stored reference electronic signals; and

determining whether to send an acoustic message associated with a matched reference electronic signal to a speaker in the vehicle based on the internal SPL.

* * * * *

EXHIBIT B

US011589329B1

(12) **United States Patent**
Goldstein

(10) **Patent No.: US 11,589,329 B1**
(45) **Date of Patent: Feb. 21, 2023**

(54) **INFORMATION PROCESSING USING A POPULATION OF DATA ACQUISITION DEVICES**

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See application file for complete search history.

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Primary Examiner — Myron Wyche
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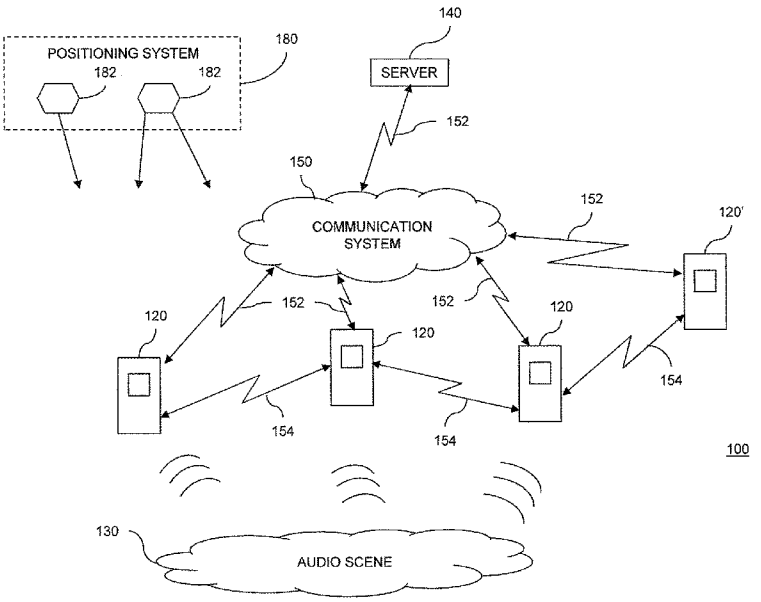
(57) **ABSTRACT**

Distributed systems, controllers and methods for processing information from a plurality of devices are provided. A distributed system includes a plurality of devices distributed in an environment. Each device has at least a communication capability for interchanging information with others of the devices and/or with a communication system. Each of at least some of the devices has one or more sensors for acquiring sensor data related to the environment proximate to the device. At least one of the communication system or one or more of the devices is configured as a controller configured to: select a subset of devices from among the plurality of devices, receive information based on the acquired sensor data of the selected subset, and combine the received information from the selected subset to determine a characteristic of the environment proximate to one or more of the devices.

11 Claims, 4 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/055,488, filed on Aug. 6, 2018, now Pat. No. 10,602,474, which is a continuation of application No. 13/976,636, filed as application No. PCT/US2011/068103 on Dec. 30, 2011, now Pat. No. 10,045,321.

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CPC *G06F 11/3013* (2013.01); *G06F 11/3058* (2013.01); *H04M 1/72403* (2021.01); *H04M 2250/12* (2013.01)

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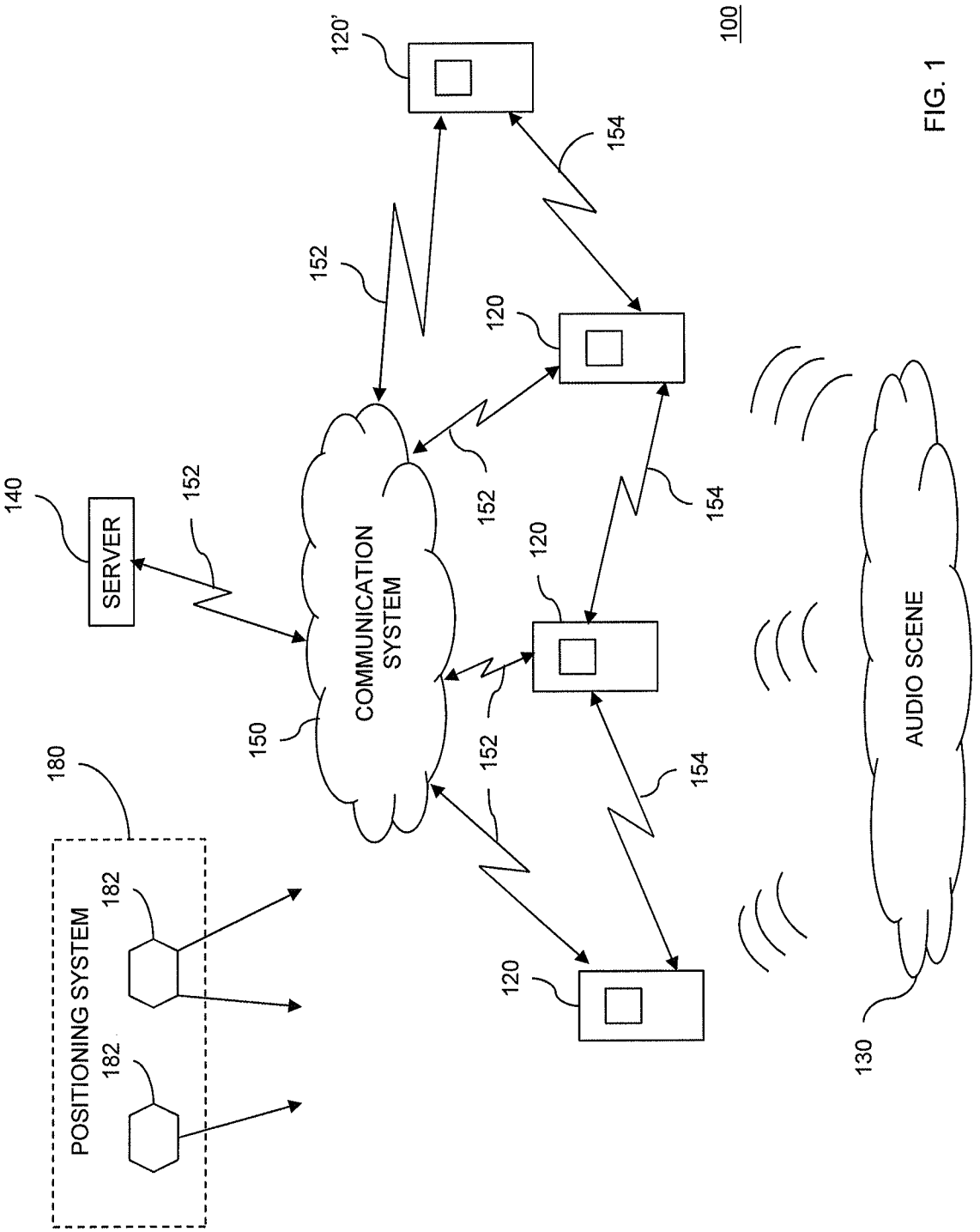
100
120'
154
152
120
152
154
140
SERVER
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COMMUNICATION SYSTEM
120
150
152
154
180
POSITIONING SYSTEM
182
182
120
AUDIO SCENE
130

FIG. 1

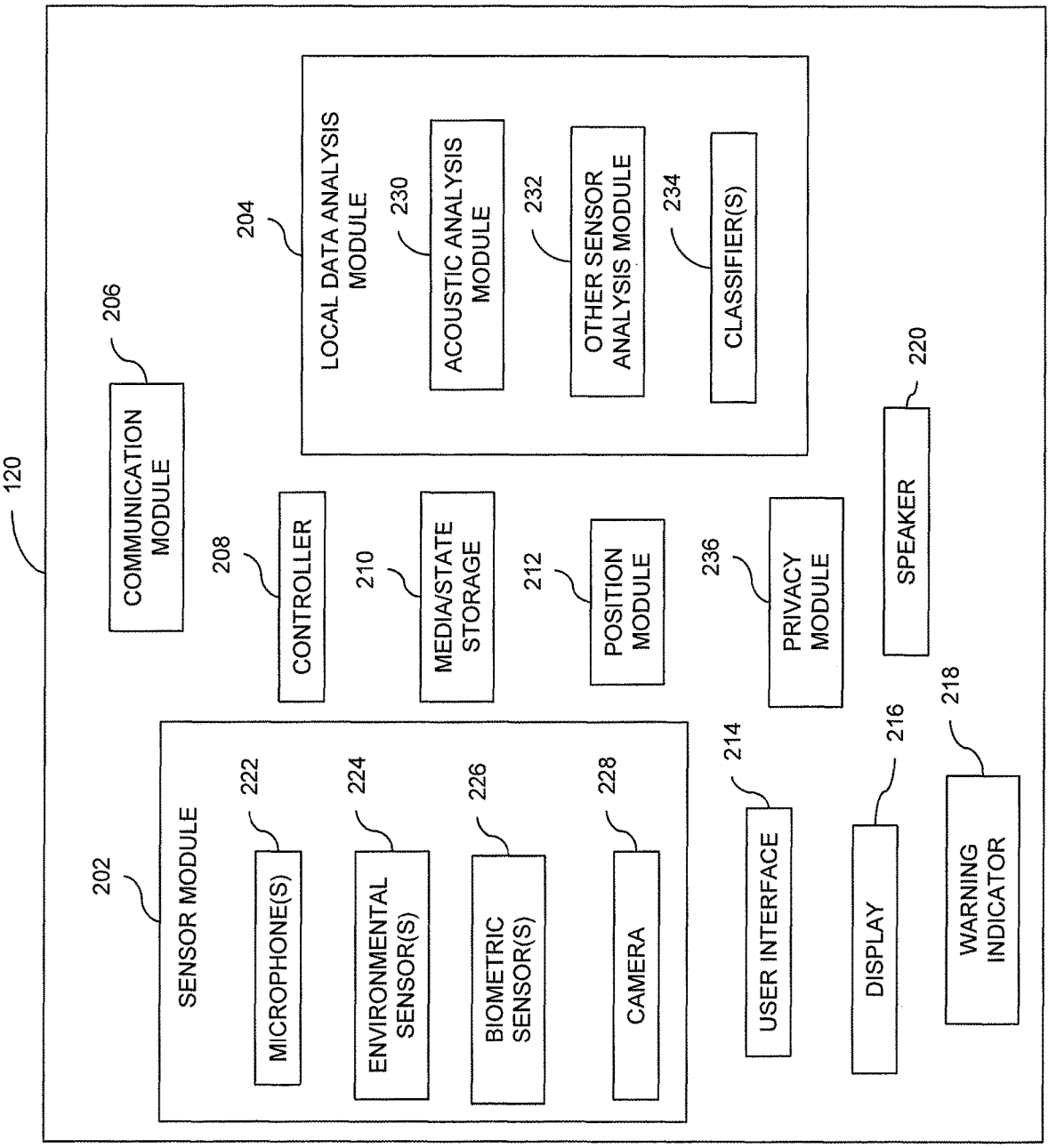
120
COMMUNICATION MODULE
206
LOCAL DATA ANALYSIS MODULE
204
ACOUSTIC ANALYSIS MODULE
230
OTHER SENSOR ANALYSIS MODULE
232
CLASSIFIER(S)
234
CONTROLLER
208
MEDIA/STATE STORAGE
210
POSITION MODULE
212
PRIVACY MODULE
236
SPEAKER
220
SENSOR MODULE
202
MICROPHONE(S)
222
ENVIRONMENTAL SENSOR(S)
224
BIOMETRIC SENSOR(S)
226
CAMERA
228
USER INTERFACE
214
DISPLAY
216
WARNING INDICATOR
218

FIG. 2A

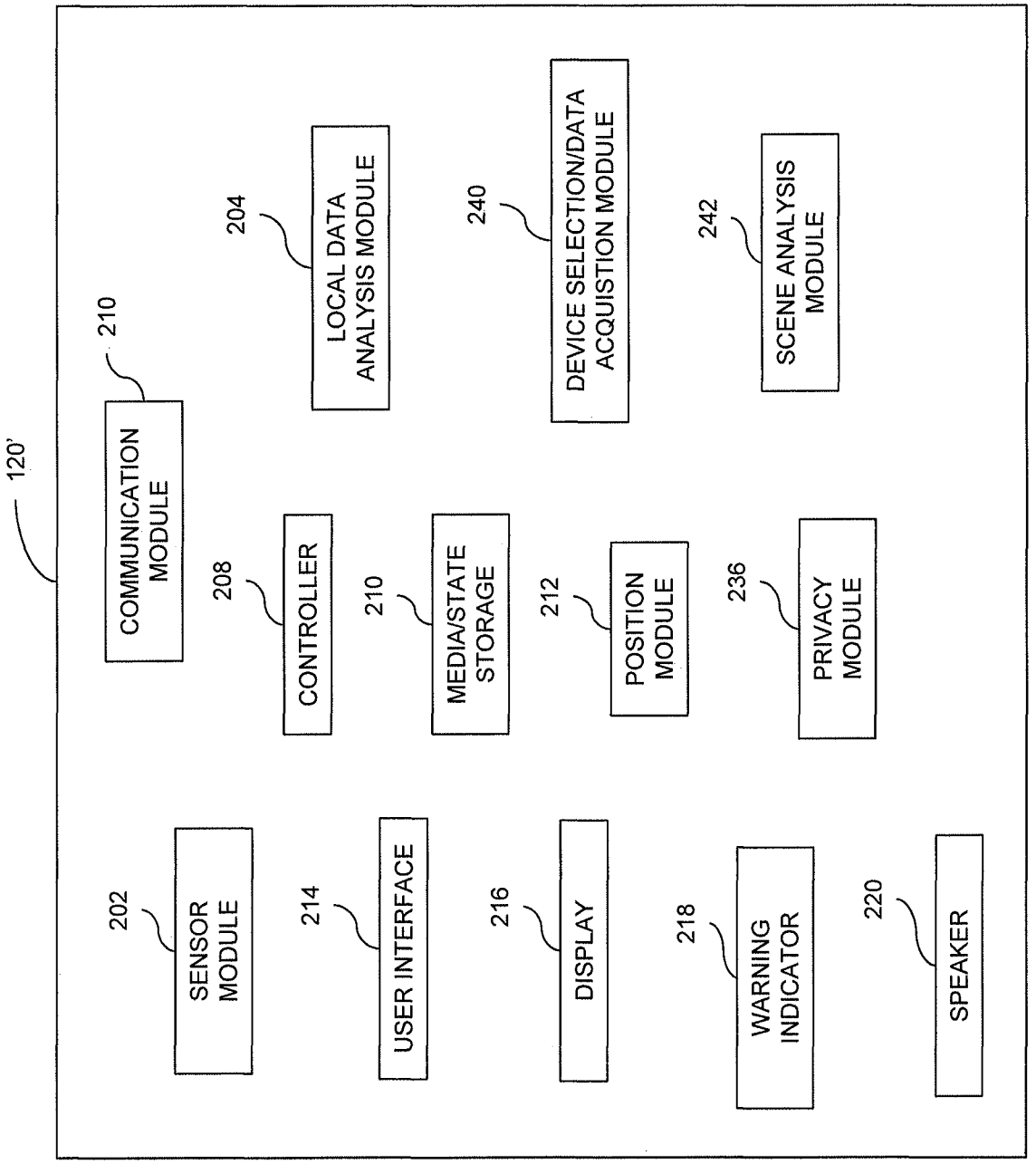
120'
COMMUNICATION MODULE
210
LOCAL DATA ANALYSIS MODULE
204
DEVICE SELECTION/DATA ACQUISTION MODULE
240
SCENE ANALYSIS MODULE
242
CONTROLLER
208
MEDIA/STATE STORAGE
210
POSITION MODULE
212
PRIVACY MODULE
236
SENSOR MODULE
202
USER INTERFACE
214
DISPLAY
216
WARNING INDICATOR
218
SPEAKER
220

FIG. 2B

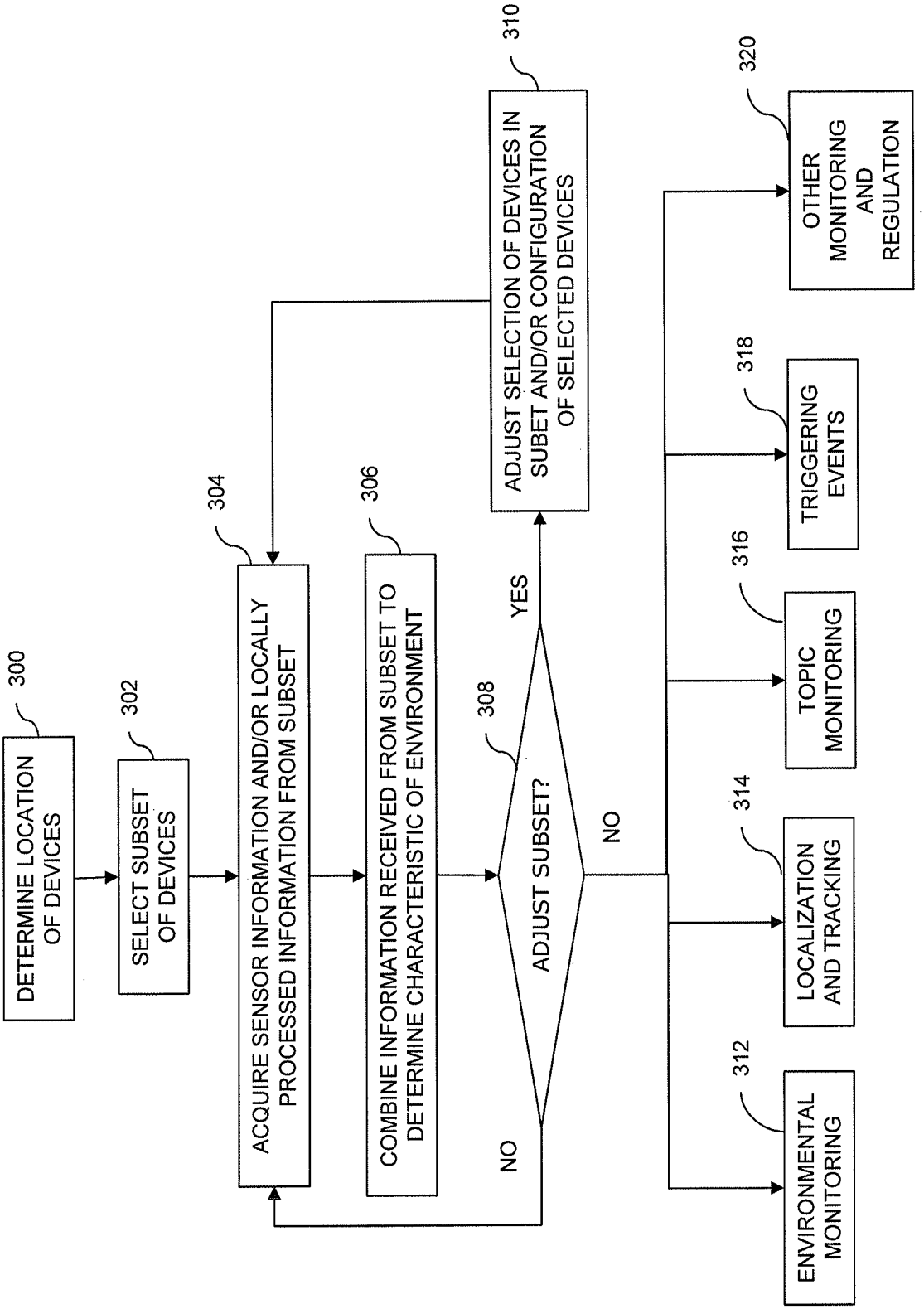
300
DETERMINE LOCATION OF DEVICES
302
SELECT SUBSET OF DEVICES
304
ACQUIRE SENSOR INFORMATION AND/OR LOCALLY PROCESSED INFORMATION FROM SUBSET
306
COMBINE INFORMATION RECEIVED FROM SUBSET TO DETERMINE CHARACTERISTIC OF ENVIRONMENT
308
ADJUST SUBSET?
YES
NO
NO
310
ADJUST SELECTION OF DEVICES IN SUBET AND/OR CONFIGURATION OF SELECTED DEVICES
312
ENVIRONMENTAL MONITORING
314
LOCALIZATION AND TRACKING
316
TOPIC MONITORING
318
TRIGGERING EVENTS
320
OTHER MONITORING AND REGULATION

FIG. 3

INFORMATION PROCESSING USING A POPULATION OF DATA ACQUISITION DEVICES

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a continuation of and claims priority to allowed U.S. patent application Ser. No. 16/736,820, filed 8 Jan. 2020, which is a continuation of and claims priority to allowed U.S. patent application Ser. No. 16/055,488, filed Aug. 6, 2018, which is a continuation of and claims priority to U.S. patent application Ser. No. 13/976,636, filed on Oct. 1, 2013, which is a National Stage Entry of PCT/US11/68103 filed on Dec. 30, 2011, which claims priority to and the benefit of U.S. Provisional Patent Application Ser. No. 61/431,507 filed Jan. 11, 2011, and which also claims priority to and the benefit of U.S. Provisional Patent Application Ser. No. 61/428,369 filed Dec. 30, 2010, all of which are herein incorporated by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates to processing of information from a population of data acquisition devices, and in some examples, relates to processing of audio or multimedia data acquired from an adaptively selectable population of personal wireless devices.

BACKGROUND

Devices that are capable of acquiring, and in some cases locally processing, audio or multimedia information from their local environment have become ubiquitous over the past several years, and there is little reason to expect that such a trend will not continue. For example, "smart" cellular telephones (e.g., Apple iPhone.RTM., Android™-operating system based phones) have significant local processing capabilities as well as audio and video acquisition devices.

SUMMARY OF THE INVENTION

In one aspect of the present invention, in general, the audio and multimedia acquisition capabilities of a set of devices may be exploited to aggregate acquired content and fuse the information in that content, for instance, for audio scene analysis. In some example embodiments, devices from a large population may be adaptively selected and/or configured according to triggering events detected at the devices or by the network. Relating to the audio scene, the information sensed and acquired from one or more devices may be processed, customized and personalized to consumers to mitigate, amplify or pass-through acoustic and other information to users, based on factors such as models of users' requirements and users' past information consumption behavior. Thus an exemplary system of the present invention may mediate ambient and explicitly supplied information, especially audio information, and may act as an arbiter of information for the user. Some of the system actions may be based on information from one device, while other actions may be based on information from multiple devices. The information filtered to users may be utilized to form virtual communities based on shared interests and common information, and to ensure that relevant information including alerts, marketing information, and news reaches these communities.

According to another aspect of the present invention, in general, a distributed system may include a plurality of distributed devices, with at least one of a communication system or one or more of the distributed devices configured as a controller. Each device has at least a communication capability for interchanging information with other of the devices and/or with the communication system. At least one of the devices may include one or more sensors for acquiring sensor data related to the environment of the device. The controller is configured to perform functions including: determining locations of at least some of the devices, selecting devices from among the plurality of devices and receiving information based on the sensor data acquired at the selected devices, and combining the information received from multiple of the selected devices to determine one or more characteristics of the environment of one or more of the devices.

In other aspects of the present invention, the distributed system may include devices that mediate all audio information sensed at the device to mitigate, amplify or pass-through information. In some examples, such information is optionally logged and analyzed to determine trend-related information.

Other features and advantages of the invention are apparent from the following description, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be understood from the following detailed description when read in connection with the accompanying drawing. It is emphasized, according to common practice, that various features of the drawings may not be drawn to scale. On the contrary, the dimensions of the various features may be arbitrarily expanded or reduced for clarity. Moreover, in the drawing, common numerical references are used to represent like features. Included in the drawing are the following figures:

FIG. **1** is a functional block diagram of an information processing system, according to an exemplary embodiment of the present invention;

FIG. **2**A is a functional block diagram of a distributed device of the system shown in FIG. **1**, according to an exemplary embodiment of the present invention;

FIG. **2**B is a functional block diagram of a controller of the system shown in FIG. **1**, according to an exemplary embodiment of the present invention; and

FIG. **3** is a flowchart diagram of an exemplary method for processing information from a plurality of distributed devices, according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

1 System Overview

Personal wireless devices, as well as other types of computing or communication devices, have become ubiquitous in our environment. Generally, such devices have a number of sensors, which may include, for instance, microphones, cameras, accelerometers, and in some cases may even have sensors for biometric information, such as heart rate. Such devices also generally include one or more communication systems, for example, a cellular telephone radio system (e.g., Code Division Multiple access (CDMA) or Global System for Mobile Communications (GSM)), a wireless local area network system (e.g., Wi-Fi, IEEE 802.11), wired computer network connections (e.g., data

network connections via USB cradles, possibly via desktop computer applications) and in some cases other systems based on radio frequency (e.g., Bluetooth.RTM.) or optical (e.g., infra-red) transmission. Finally, such devices generally are "location aware" and/or locatable by the infrastructure in which they operate. For example, such devices may have global positioning system (GPS) receivers, enhanced GPS (which operates in conjunction with cellular telephone infrastructure), and/or Wi-Fi based maps (which use a map of Wi-Fi access points to locate the device). The cellular infrastructure may, for example, be able to locate the device based on cellular signal strength and/or triangulation approaches.

In some aspects of the present invention, the combination of characteristics of these devices provides a potentially rich source of information that may be combined in a way that generates valuable information that is not necessarily available to any individual device. As an illustrative example, audio processed locally at many different devices may be combined to identify geographic or social group trends based on keywords spoken or other acoustic events (e.g., coughs) that are detected at the devices.

Detection of coughs is an example where detection of non-speech acoustic events may be useful. Because a cough is often a sudden and often repetitively occurring reflex, frequent coughing may indicate the presence of a disease (e.g., many viruses and bacteria benefit evolutionarily by causing the host to cough, which helps to spread the disease to new hosts). Most of the time, coughing is caused by a respiratory tract infection but can be triggered by choking, smoking, air pollution, asthma, gastro-esophageal reflux disease, post-nasal drip, chronic bronchitis, lung tumors, heart failure and medications such as ACE inhibitors. Detection of such events in the vicinity of the devices may provide significant information.

In other aspects of the present invention, the rich sensor capabilities of the devices may provide a way to track activity of a user (e.g., owner) of the device, to enhance the user's experience with various computing applications (such as searching or personalization). As an illustrative example, topics of conversation in the vicinity of the device may affect the ranking of search results or the ordering of presentation of news stories on the device.

In some aspects of the present invention, the rich source of information over many devices and the tracking of individual activity may be combined, to benefit from their synergy.

Referring to FIG. **1**, a functional block diagram of an exemplary information processing system, designated generally as system **100**, is shown. System **100** may include one or more distributed devices **120** (also referred to herein as devices **120**) and device **120'** (also referred to as controller **120'**) in an environment. One or more of devices **120** and device **120'** may be configured to acquire information relating to audio scene **130**. Device **120'** may be the same as device **120**, except that device **120'** may be configured to act as a controller for selectively acquiring sensor information from among devices **120** and for determining a characteristic of audio scene **130**. Although one device **120'** is illustrated as being a controller, it is understood that multiple devices **120'** may act as controllers.

Although device **120'** is illustrated as a controller for gathering sensor information and determining a characteristic of audio scene **130**, it is understood that communication system **150** and/or server **140** may also be configured to act as a controller. Communication system **150** or server **140** may collect at least one of sensor information from devices **120**, **120'**, local data analysis information from devices **120**, **120'** or scene analysis information from device **120'**.

Devices **120** and device **120'** may be capable of direct communication with each other, via communication link **154**. Devices **120** and device **120'** may also be capable of communication with communication system **150**, via communication link **152**. Devices **120** and device **120'** may also be in communication with central server **140**, via communication system **150** and communication link **152**. Devices **120**, **120'** may include wired or wireless devices. As discussed further below, devices **120**, **120'** may be at fixed positions or may be mobile devices.

In one exemplary embodiment, a number of devices **120** are present in an environment. In some examples, the devices **120** (and device **120'**) are cellular telephones (e.g., "smartphones"). The environment represented by audio scene **130** may be an urban environment, for example, with the devices **120**, **120'** being present on city streets, in office buildings, or in homes of the users. Generally, the devices **120**, **120'** may be personal to the users/owners (of the devices), and may be mobile devices, carried with the user throughout the day.

In FIG. **1**, a small number of representative devices **120**, **120'** are illustrated. As discussed further below, the potentially enabled devices **120**, **120'** may be part of a large population of devices (e.g., a large fraction of the telephones in a metropolitan area) and system **100** may adaptively enable particular subsets of the devices **120** and/or selectively configure enabled devices **120**. For instance, device **120'** (or server **140**) may enable and/or configure the devices **120** according to triggering events detected at one or more devices **120**, **120'**.

It should be understood that the description below focuses on smartphones as an example, and other types of fixed or mobile devices may be used in conjunction with or instead of smartphones. Also, the description below focuses on aggregation or combination of audio information as an example, but aggregation and processing of other forms of information, including video and biometric information may be performed in conjunction with or instead of the audio data examples described below.

As introduced above, any particular device **120**, **120'** is able to sense some aspect of an overall audio "scene" in its environment. Such a scene may include, for example, the device owner's own speech even when not carrying out a telephone call, other sounds made by the owner (such as coughing), the speech of others in proximity to the user and environmental sounds in proximity to the user (such as sirens, gunshots, etc.).

Generally, system **100** makes use of the audio acquisition capabilities of one or more of the devices **120**, **120'** in order to extract information related to the views of the audio scene **130** by the one or more devices **120**, **120'**. In one exemplary approach to acquisition of the raw content, every device **120** could continually transmit its acquired signals over communication system **150** to a central server **140** (via communication link **152**). For example, the communication system **150** may comprise a cellular telephone system and/or a wireless data network. However, such continual transmission may not be feasible due to the sheer volume given the large number of devices **120**, **120'** that are fielded, and may raise other issues regarding privacy of those in the environments of the devices **120**, **120'**.

Another exemplary approach to extracting information is for each device **120**, **120'** to perform a local signal analysis based on the signals acquired by that device. However, such an approach may have limitations due to the computational

limitations of the devices **120**, **120'**. Also, a purely local processing may lose advantages that could be gained by fusing of information from multiple devices **120**, **120'**

An exemplary approach describe below addresses some of the limitations of a purely local or a purely centralized approach using a combination of one or more of the following features: [**0028**] **1**) Local processing of acquired signals (on devices **120**), at least to identify occurrences of events that may be of interest; [**0029**] **2**) Local buffering of audio for selective transmission to device **120'** or central server **140**, for example, on an ongoing basis or based on a request from device **120'** or server **140**, or based on local identification of a local event (at one or more of devices **120**); and [**0030**] **3**) Selective enabling of acquisition and/or processing (or specification of the type of processing) at particular devices **120**, **120'**, for example, based on their geographic location and/or other proximity metrics (e.g., a social network rather than a geographic distance metric).

Note that the locations of the devices **120**, **120'** (e.g., three-dimensional coordinates) are generally known by the devices **120**, **120'** and/or central server **140**. As an example, a positioning system **180** makes use of units having known locations, such as GPS satellites **182**, fixed cellular transmission towers, Wi-Fi access points, etc. to maintain an estimate of the positions of the devices.

Referring to FIG. **2**A, a functional block diagram of exemplary device **120** is shown. Device **120** may include one or more of sensor module **202**, local data analysis module **204**, communication module **206**, controller **208**, media/state storage **210**, position module **212**, user interface **214**, display **216**, warning indicator **218**, speaker **220** and privacy module **236**.

A typical device **120** includes communication module **206**, which provides a communication link **152** through the communication system **150** to sever **140** and/or a communication link **154** to other devices **120**, **120'**. Communication module **206** may also serve a role in acquiring positioning signals (e.g., GPS signals, Wi-Fi signal strengths, etc.), and may also provide a way to communicate directly with other devices **120**.

Device **120** may include sensor module **202** for the acquisition of sensor information. Sensor module **202** may include one or more microphones **222** for collecting acoustic information regarding audio scene **130** (FIG. **1**). Sensor module **202** may also include one or more environmental sensors (such as a temperature sensor, a motion sensor such as an accelerometer) for collecting environmental information associated with device **120**. Sensor module **202** may also include one or more biometric sensors **226** (such as heart rate) for sensing biometric information regarding a user of device **120**. Sensor module **202** may also include camera **228** (i.e., an image sensor) for capturing still images and/or video of the surrounding environment of device **120**. Sensor module **202** may also include a compass for providing location information. In general, sensor module **202** may include any sensor capable of measuring a physical quantity and converting it into a signal that may be used by system **100**. For example, sensors in sensor module **202** may also include, without limitation, one or more of light detection sensors, proximity sensors, gravity detection sensors, a magnetic field detection sensors, electrical field detection sensors, vibration sensors, pressure sensors, humidity sensors, moisture sensors, toxin detection sensors, nutrient detection sensors or pheromone detection sensors.

User interface **214** may include any suitable user interface capable of providing parameters for one or more of sensor module **202**, local data analysis module **204**, communication module **206**, media/state storage **210**, position module **212**, display **216**, warning indicator **218**, speaker **220** and privacy module **236**. User interface **214** may include, for example, a pointing device, a keyboard and/or a display device.

Device **120** may include display **216**, warning indicator **218** and/or speaker **220** for presenting information to a user of device **120**. Display **216** may include any suitable display device capable of presenting information on device **120**. Warning indicator **218** may include any suitable visual indicator for presenting a warning on device **120**. The warning may include, for example, an indication that audio information is being recorded. It is understood that speaker **220** may also audibly present a warning indication. Although user interface **214** and display **216** are illustrated as separate devices, it is understood that the functions of user interface **214** and display **216** may be combined into one device. According to an exemplary embodiment, device **120** may receive acoustic and/or other information (via display **216**, warning indicator **218** and/or speaker **220**) that has been mitigated, amplified and/or passed to device **120** from device **120'** (FIG. **1**) based on information acquired from one or more devices **120**.

Device **120** may include position module **212**, to maintain a position estimate for device **120**. For example, position module **212** may use positioning system **180** (FIG. **1**) to obtain the position estimate.

Media/state storage **210** may store at least one of raw sensor information (from sensor module **202**), locally analyzed information (from local data analysis module **204**) or location information (from position module **212**). Media/state storage **210** may include, for example, a magnetic disk, an optical disk, flash memory or a hard drive.

Controller **208** may be coupled, for example, via a data and control bus (not shown) to one or more of sensor module **202**, local data analysis module **204**, communication module **206**, media/state storage **210**, position module **212**, user interface **214**, display **216**, warning indicator **218**, speaker **220** and privacy module **236**. Controller **208** may be configured to control acquisition of sensor information, local analysis of sensor information, transmission and/or receipt of sensor information, transmission and/or receipt of local analysis information, as well as any presentation of information by device **120** (such as via display **216**, warning indicator **218** and/or speaker **220**). Controller **208** may include, for example, a logic circuit, a digital signal processor or a microprocessor. It is understood that one or more functions of local data analysis module **204** may be performed by controller **208**.

Local data analysis module **204** may be configured to analyze information collected locally by sensor module **202** for device **120**. Local data analysis module **204** may include acoustic analysis module **230** for analyzing audio information (such as from one or more microphones **222**). The audio information may include speech, music as well as environmental sounds (such as an approaching train). The speech may be generated by a user of device **120**, as well as by other individuals proximate to device **120**. Local data analysis module **204** may perform the analysis either locally or with the aid of backend server architecture or similar mechanisms.

Local data analysis module **204** may also include other sensor analysis module **232** for analyzing information from other sensors of sensor module **202**. For example, other sensor analysis module **232** may analyze information from one or more of environmental sensor(s) **224**, biometric sensor(s) **226** and/or camera **228**. Local data analysis module **204** may combine results from acoustic analysis module

230 (such as keywords, target sounds) and other sensor analysis module 232 to determine the occurrence of one or more particular events (and/or a characteristic of audio scene 130).

Acoustic analysis module 230 and/or other sensor module 232 may also pre-process the respective sensor information, for example, to substantially remove or reduce noise. Modules 230, 232 may also filter the noise-reduced sensor information to identify high value signals which may be indicative of the occurrence of particular events.

Local data analysis module 230 may include classifiers 234 associated with acoustic analysis module and/or other sensor analysis module. Classifiers 234 may be used to build profiles of audio information, environmental information, biometric information and/or image information.

In an exemplary embodiment, acoustic analysis module 230 may preprocess the audio information to recognize speech, perform keyword spotting on speech information, and in addition build voice models of various speakers within the auditory range of the device. The models may, for example, use classifiers 234 and machine learning methods to identify gender, probable age range, nationality and other demographic features from the speech signals.

In addition, there may be classifiers 234, for instance, to recognize any slurring due to the influence of alcohol or similar substances, accent classifiers to detect and identify accent patterns belonging to specific language groups, and emotion classifiers to classify speakers and speech into happy, sad, stressed, angry or other emotional states. Thus, given any audio input that includes any speech, individual devices 120 or system 100 (FIG. 1) as a whole may be able to build an acoustic profile of each speech participant in that input, where the profile not only includes the keywords spotted, but also other data such as demographic data about each speaker including gender, probable age, possible nationality etc., as well as classifier results about emotional state, and/or whether the speaker is under the influence.

The acquisition of keywords with demographic data may help advertisers target their sales, based on factors such as gender, age and potential levels of disposable income, and to track their sale cycle from users noticing their advertisements to those users who actually make a purchase. Emotion indicators may be used to take palliative or preventative steps to avoid customer dissatisfaction. Other information like slurring may be used as corroboratory information in situations such as accidents or may be used to prevent accidents.

Privacy module 236 may include mechanisms to implement privacy and/or security requirements and policies for applications relating to the acquisition and use of information of various kinds, including audio information, by one or more devices associated with a number of carriers. These policies and mechanisms may control the use of devices 120 (and device 120' (FIG. 1)) including the ability to remotely switch on and switch off sensing (e.g., listening), the ownership of any audio information garnered by these devices 120 (and device 120' (FIG. 1)), the users' ability to easily control sensing and information acquisition, mechanisms to opt-in and opt-out of applications, carrier-wide or network-wide data gathering, the protection of any audio personally identifiable information (PII) that is gathered, and any aggregated data that is created from a number of devices 120 (device 120' (FIG. 1) and networks. Policies or standard practices may also be established for private or semi-private situations where not all users present have opted-in for data acquisition. For example, when system 100 (FIG. 1) records speech from users that are not likely to be opted-in to the information acquisition, system 100 may provide a warning indication to all devices 120 in the immediate vicinity to indicate that audio information is being recorded. The warning indication may be provided on warning indicator 218.

Referring next to FIG. 2B, a functional block diagram of exemplary device 120' is shown. Device 120' is similar to device 120 (FIG. 2A), except that device 120' may also include device selection/data acquisition module 240 and scene analysis module 242. Similarly to device 120 (FIG. 2A), components of device 120' may be coupled together via a data and control bus (not shown).

Device selection/data acquisition module 240 (also referred to herein as module 240) may receive sensor information and/or locally analyzed information from selected devices 120 (FIG. 1). Scene analysis module 242 may combine the sensor information and/or locally analyzed information from among the selected devices, in order to determine at least one characteristic of audio scene 130 (or the environment, in general).

Module 240 may determine the locations of at least some of devices 120 (FIG. 1). Module 240 may select one or more devices 120 (FIG. 1) from among plural devices 120, for example, based on the location of these devices 120 as well as any characteristics (such as an event) determined by scene analysis module 242. Accordingly, as a characteristic is detected (by scene analysis module 242), module 240 may adaptively acquire information from selected devices 120 (FIG. 1), in order to better analyze audio scene 130. Module 240 may also configure selected devices 120 (FIG. 1) to acquire specific information, (for example one device 120 may acquire image data via camera 228 (FIG. 2A) whereas another sensor may be configured to acquire audio data via microphone 222 (FIG. 2A). As another example, module 240 may configure multiple devices 120 to acquire audio data via respective microphones 222 (FIG. 2A), so that the multiple microphones 222 form a beam forming array.

Referring generally to FIGS. 1, 2A and 2B, system 100 makes use of one or more of enabling and configuring of devices (via device selection/data acquisition module 240) for prospective monitoring, access to logged data for retrospective analysis, and real-time notification of events (such as by scene analysis module 242). This adaptation of system 100 may be based on detection of triggering events at the devices 120, 120'. For example, device 120' may enable detection of certain acoustic events (e.g., words, spoken topics, music, and environmental sounds) and may adapt the configurations on selected devices 120 based on reports from other devices 120.

Device 120' (and devices 120) may include software for coordinating the set of devices 120. The software may have centralized control, peer-to-peer control or a hybrid model involving centralized, peer-to-peer and other control mechanisms. Individual devices 120, 120' may switch between being master devices controlling other devices, or slave devices under the temporary partial control of other devices. The network of devices 120, 120' may so configure itself to optimize power consumption on individual devices 120 by distributing the sensing load across a number of devices 120, 120', or by other mechanisms such as sharing bandwidth across devices 120, 120'. The networking used may be based on ideas related to mobile ad hoc networks (MANET), Scatternet or other mechanisms.

For example, system 100 may dynamically organize and reorganize its nodes into hierarchies or graphs, with some devices 120, 120' chosen to be master nodes while other possibly geographically proximate devices to be slave nodes. Slave nodes may perform actions based on instruc-

tions from master nodes. They may preprocess information and convey processed information to master nodes, instead of conveying all information acquired, thus distributing computation among nodes and reducing the communication bandwidth. In addition, communication requirements may improve because only a few master nodes may communicate with each other, instead of all, say N devices trying to communicate with each other, which would require (N.sup.2/2) connections.

Because each node knows its location, depending on system requirements, the network may organize itself into one or more linear chains or local groups, where information is passed between physically proximate devices, very much like a bucket brigade conveying information. With a peer-to-peer architecture, individual devices **120**, **120'**—either just master nodes or both master nodes and slave nodes—may record information about neighboring nodes and their capabilities and features, so that, for instance, connectivity between any pair of nodes can easily and effectively be established at low computational cost.

Other optimization techniques may also be adopted—for instance, when data logs are recorded, the system may determine if several devices are in the same audio or other sensor context. For example, if several phones **120**, **120'** are located in the same context, not every phone **120**, **120'** has to record all data—the system **100** may designate a scribe node which acts as a local repository for data and for ensuring the data gets stored to some centralized server **140** (or device **120'**) in the cloud. This may save considerable logging effort on the part of the other nodes.

Alternatively or in addition, the system **100** may distribute sensor load among devices **120**, **120'** so that not every node has to acquire information via all of its sensors in sensor module **202**. Some sensor modules **202** may concentrate on acquiring audio information, while other devices **120**, **120'** may acquire position information and still other sensor modules **202** may acquire temperature or altitude information, and so on. This may reduce power and communication bandwidth requirements for the entire system **100**. Several such schemes may be devised to optimize the throughput and efficiency of the system as a whole. According to an exemplary embodiment, system **100** may also distribute processing of sensor information among devices **120**, **120'**, so that different individual tasks are performed by devices **120**, **120'**. This may reduce the computational burden on some devices **120** (or device **120'**) which may not have suitable processing capabilities for a specific task.

The system **100** as a whole may use carrier-agnostic handlers in the cloud. Specifically, the networking may utilize services from a number of wireless telephony, Wi-Fi or other carriers, and suitable policies may be put in place to enable carrier-agnostic behaviors. Specifically, so that no user may be denied sharing of information because of association with specific carriers, and so that digital bridges exist to share information across carriers where desired. In a variant, some features may be made unique to a carrier for marketing reasons.

It is understood that devices **120**, **120'** do not have to be phones. Devices **120**, **120'** may be stand-alone devices, or may be an integral part of a GPS, hearing aid, mobile phone, TV remote, car key fob, portable game controller or similar device. Device **120** (and/or device **120'**) may be carried by the user on his person, or be installed in or on a vehicle such as a car.

For certain applications, devices **120** (and/or device **120'**) may be fixed and installed at home, or be part of fixed telephones, desktop computers, TV sets or game consoles. Each device **120** (and/or device **120'**) may include one or more sensors with associated software. Different kinds of devices **120**, **120'** may include different sensors and/or different software. If device **120** or device **120'** is more like a smartphone, system **100** may have access to textual data including electronic mail, chat transcripts and documents, and audio data including phone conversations, music on the device or streamed to the device, ambient audio picked up by microphones, and user search logs. All of this data may be relevant to the user. This data, along with the user's context and environmental variables, may be used for personalization of information consumed by the user and then where appropriate repurposed for commercial applications to the user or the community at large.

Referring to FIG. **3**, a flowchart diagram of an exemplary method for processing information from a plurality of distributed devices is shown. The steps illustrated in FIG. **3** represent an example embodiment of the present invention. It is understood that certain steps may be performed in an order different from what is shown. It is also understood that certain steps may be eliminated.

At step **300**, the location of devices **120** (FIG. **1**) may be determined, for example, by controller **120'** based on information previously received from devices **120**. For example, controller **120'** (FIG. **1**) may directly communicate with devices **120** to determine their locations. As another example, the location of devices **120** (FIG. **1**) may be known from communication with communication system **150** and/or sever **140**.

At step **302**, a subset of devices **120** (FIG. **1**) may be selected, for example by device selection/data acquisition module **240** (FIG. **2**B) of controller **120'**. For example, controller **120'** (FIG. **1**) may select one or more devices **120** based on a predetermined characteristic of the environment and the location of devices **120**.

At step **304**, sensor information and/or locally processed information may be received by controller **120'** (FIG. **1**) from the selected subset, for example, by device selection/data acquisition module **240** (FIG. **2**B). For example, controller **120'** (FIG. **1**) may receive raw sensor information from respective sensor modules **202** (FIG. **2**A) and/or locally processed information from respective local data analysis modules **204** (FIG. **2**A). Controller **120'** (FIG. **2**B) may also acquire sensor information and/or locally processed information from its own sensor module **202** and local data analysis module **204**. The information from at least one of the devices **120** may be received responsive to a confirmation indication from the respective device **120**, to indicate an allowance by device **120** to release its respective information to the controller. For example, the confirmation indication may be provided manually by a user of the respective device **120**, or may be provided automatically by the respective device **120**, based on the privacy settings of the device **120**.

At step **306**, information received from the subset (as well as, optionally, from controller **120'** (FIG. **1**)) is combined to determine a characteristic of the environment, for example, by scene analysis module **242** (FIG. **2**B) of controller **120'**.

At step **308**, it is determined whether the subset should be adjusted, for example, by device selection/data acquisition module **240** (FIG. **2**B) of controller **120'**. For example, the subset may be adjusted based on an event detected by a local data analysis module **204** (FIG. **2**A) of one or more devices **120**, the characteristic of the environment, any context from the characteristic, the location of devices **120** (FIG. **1**) (e.g., position, orientation in space), demographics from the characteristic, any social-graph membership among devices **120**,

etc. For example, if one device **120** (FIG. **1**) detects a gunshot, device **120'** may expand the subset of devices **120** to additional devices (to triangulate the location of the gunshot) and/or to send a warning indication to all devices **120** in range.

If it is determined, at step **308**, that the subset should be adjusted, step **308** proceeds to step **310**. At step **310**, selection of the devices in the subset may be adjusted and/or a configuration of selected devices of the subset may be adjusted, for example, by device selection/data acquisition module **240** (FIG. **2**B). For example, different devices **120** (FIG. **1**) may be switched on or off. As another example, different sensors of sensor modules **202** (FIG. **2**A) may be configured to acquire sensor information.

If it is determined, at step **308**, that the subset should not be adjusted, step **308** may proceed to step **304**, to continually determine a characteristic of the environment.

Alternately, step **308** may proceed to step **312** (environmental monitoring), step **314** (localization and tracking), step **316** (topic monitoring), step **318** (triggering events) and/or step **320** (other monitoring and regulation). The characteristic of the environment may be used for a number of different applications, which are described further below.

Referring generally to FIG. **1**, in an exemplary embodiment, a platform may be developed to enable users to develop applications that: harness a set of these devices **120**; acquire signals from devices **120**; switch subsets of devices **120** on or off (based on information about context, including position, orientation in space, social-graph membership, and demographics); process and analyze information obtained from sensors of devices **120**; set triggers to enable or disable sensing, processing or analysis; and adapt system **100** to sensed, processed or analyzed information. The platform may allow individual devices **120**, **120'** to be customized and personalized to users (consumers) to mitigate, amplify or pass-through acoustic and other information to users based on acoustic and other information acquired from one or more devices.

Once such a platform is developed, applications may be developed for many of the scenarios and use-cases described herein. The platform may specify minimum hardware requirements, such as minimal sensor numbers and configuration, minimal onboard computing resources in terms of hardware and software, and an application programming interface (API) to allow developers to access all the features and resources available on the device.

An example platform specification may include: one or more microphones or a microphone array; one or more accelerometers typically to cover two or three axes of motion or orientation; a compass; an on-board GPS system; zero or more other sensors such as contact or non-contact temperature sensors; cameras with a minimal required resolution, with Bluetooth.RTM., Wi-Fi and other capabilities; software including classifiers to analyze speech, to analyze media including music, video, and still images; software to acquire environmental metrics and analyze them in various contexts such as urban vs. suburban, and residential vs. industrial; software to preprocess signals acquired to remove or reduce noise, filter the remaining signals to identify high value signals and to transmit them to a server **140** in a compressed form if desired; a database of sound signatures; and software to handle reactive mechanical tasks in response to sensor data—all with enough power to provide a realistic and acceptable user experience.

2 Example Use Cases

In this section, a number of example use cases are provided to illustrate how an exemplary system **100** (FIG. **1**), described above, may be used in practice.

2.1 Environmental Monitoring A number of uses relate to monitoring an environment of a set of smartphones. In a public health monitoring example, the on-board audio processor may be configured detect occurrences of coughs, typically by the owner of the device or by other people in the proximity of the device. Such detection may use, for example, statistical spotting techniques (e.g., Hidden Markov Model (HMM) techniques, Gaussian Mixture Model (GMM) techniques) trained on a corpus of recordings of coughs know as a Universal Background Model. Communication of locally aggregated results, for example, a number of coughs per hour, may be uploaded to the central server **140** or device **120'** on a schedule, or when the rate deviates from an expected or maximum value. In this way, the controller **120'** (or server **140**) may be able to identify local "hot spots" of coughing.

Other educational and public health uses may be possible with epidemiological applications of such systems. For example, pertussis (whooping cough) is a highly contagious disease and one of the leading causes of deaths world-wide that is preventable with the use of vaccines. Exemplary system **100** may be used to provide information to parents of children with coughs or with other symptoms such as asthmatic symptoms to help them decide when to seek medical help, and to provide epidemiological data about pertussis, asthma and related illnesses.

In some scenarios of such monitoring, only a limited subset of devices may be initially configured to perform the local processing needed to detect the coughs. However, when controller **120'** determines that there is a possible hot spot of activity, controller **120'** may enable further devices in the geographic proximity of the hot spot to gain further information about the extent of the situation. In some examples, the controller **120'** may enable further devices based on a social proximity, for example, to account for the possible transmission of an illness to others that are close in a social sense. In addition to enabling further devices, the controller **120'** may disable devices and control the overall monitoring set for the task.

In a variant, the system **100** may use sensed information to alert patients to asthmatic attacks in children, along with information on the child's environment at the onset of the attack, to enable them to ensure that prompt remedial or palliative action is taken.

In yet another variant, the system may be used to alert patients of breathing disorders such as sleep apnea. Sleep apnea is a disorder that is characterized by abnormal low breathing or abnormal pauses in breathing during sleep, often accompanied by snoring. Often the snorer is not aware that they snore or that they could have a life threating medical issue, and they suffer from fatigue, daytime sleepiness and other symptoms, often for years and years. Diagnosis often requires an overnight sleep study in a special lab set up with sensors. Knowledge about snoring and having a record of snoring behavior can help in the diagnosis and remediation of this condition. System **100** may be trained to recognize snoring, and to distinguish it from other kinds of similar noises, and help in detecting and recording snoring behavior to help people with breathing disorders identify their problems and seek appropriate help.

In another monitoring use case, the devices **120** may be used to monitor environmental sound levels (e.g., sound pressure level), for example, for workers in a factory work-

place. Devices **120** of workers monitor the noise level and maintain a record, for example, cumulative durations of various ranges of noise level. This locally-determined information may be provided on regular or locally triggered basis, for example, if the noise level exceeds certain prescribed limits (e.g., an absolute limit, a limit for accumulated time above a prescribed sound pressure level, etc.). The controller **120'** (or server **140**) may query further devices **120** to determine the location of high noise levels, for example, based on locally logged detailed information that correlate noise level and location within the workplace. Also, other characteristics of environmental sound, for instance, related to the source of the sound may be detected. For example, a machine type (e.g., whistle, engine, press, saw, drill etc.) may be discriminated, for instance using pattern matching techniques (e.g., HMM, GMM techniques).

A similar sound-level monitoring may be used to track environmental sounds levels, for example, in particular restaurants, on particular streets, etc. and such monitoring may also identify time-of-day variation of such levels. Ornithologists may be interested in the ability to monitor the presence or absence of bird songs over time and space. Others might be interested in using sound arrays to monitor insect infestations. Exemplary system **100** may make it possible to compare treatment areas with controls to measure the effectiveness of proposed countermeasures. In some examples, if the device **120** is not connected to the communication system **150**, information is logged, time stamped and stored in a non-volatile memory and then uploaded when the device **120** is once again connected or its memory is interrogated. This may be typical after an automobile accident or other fatal or non-fatal incidents.

If a large number of cars on the same highway suddenly decelerate at the same time, then the network could decide to issue a warning to cars a few miles behind the obstacle. In addition, the ability to measure traffic flow using an array of smartphones (equipped with communication networks and sensors such as accelerometers and microphones and GPS/location sensors) has the potential to improve traffic routing in the short term, and traffic planning in the long term. Many of the applications envisioned in the present invention may have both short-term and long-term benefits. Short-term benefits use networks with low latency (such as the radio stack), whereas long-term applications can make use of networks with longer latency (such as uploading information at the end of the day when the device is docked in a networked cradle).

In another monitoring use, phones may be enabled to "name that tune" in the environment, and both provide the owner to download that song to their device library and upload the location of the playing to the central controller, which monitors the aggregated presence of different songs. Consider a music festival with several stages, where different groups are playing. As the user walks around these stages, a network of systems may be continuously acquiring audio data, detecting and isolating, for instance, music, identifying the music and showing users the name of the piece being played, the album, the artistes playing etc. The system may provide a mechanism for users to purchase the music if it is of interest to them. There are stand-alone programs to identify music being played, but they require a single device to collect a good sample of music, send it to a server and then possibly identify the music. In contrast, by having a network of devices **120** collect data, data acquisition is more robust and distributed, and users are able to get their music identified faster.

Detection of particular music being played in the environment of devices may be aggregated to determine marketing related information. By monitoring what people hear as they go about their lives, the system may acquire considerable information about the media segment. The information captured on music played, the artiste/group being played, the volume of music purchased etc. is very valuable, especially when pivoted on various dimensions. In addition, in stores where music is sold, features such as the audio background and lingering behavior may also be valuable.

These devices may also be used to share information about what users listen to or see, or to find out what their friends are seeing or listening to. Currently users have to take the effort to tweet or post their music-playing or video-watching behavior. However, a few days of this can get tedious, and soon users may no longer post information on their listening or viewing habits. Exemplary devices **120** may automatically identify songs or TV programs, inform friends in the users' social graph or create virtual communities of users with similar listening or viewing interests.

2.2 Localization and Tracking

Some use cases take advantage of the multiple locations of the devices **120** to perform localization and/or tracking of audio sources. In one example, aircraft noise data may be obtained by having a "jet detector" implemented in the on-board audio processor of a set of devices **120**. Upon detection of a loud jet noise, which is reported to the controller **120'** (or server **140**), other devices **120** in the proximity of the reporting device(s) **120** are enabled. Buffered time stamped audio and device location data is uploaded to the controller **120'** (or server **140**), where a triangulation approach may be used to determine a track of the detected audio source. Based on the track, further devices **120** may be enabled along the project track so that the audio source may continue to be tracked. If the source is lost (i.e., doesn't follow a predicted tract), more devices **120** over a larger area may be enabled to re-acquire the location of the audio source. In this way, an overall assessment of the audio tracks of loud aircraft may be determined based on the aggregated acquired audio data.

The selected set of devices **120** effectively acts as a configurable microphone mesh for acquiring audio data. In other examples, the devices **120** can act as a configurable accelerometer mesh for acquiring spatially and/or temporally distributed motion-related data.

Similar tracking information may be used, for example, to track sirens in a city. Such tracking may be used, for example, to predict traffic flow in a city that may be affected by an emergency.

Another type of localization may be used in near real-time or in an after-the-fact forensic mode. For example, the devices **120** may be carried by police officers or bystanders near the scene of a shooting. After detection of a gunshot event by one or more of the devices **120** (e.g., the officers' devices), the controller **120'** (or server **140**) may upload locally buffered audio from the officers' devices **120** or other devices **120** in the environment, and perform a localization of the source of the shooter's location. In a near real-time example, this information may be provided to the police officers to aid in their police duties. A similar type of arrangement may be used in a military situation in which audio is buffered at devices **120** carried by multiple soldiers, and the combined information may be used to estimate the direction of a sniper location.

Note that a central server **140** is not necessarily required. For example, devices **120** may locally exchange information to perform aggregated analysis, such as localization. In one

such example, each device **120** may include a detector for an event of interest (e.g., gunshot), and upon detection of the event may pass the raw audio or a partially processed version of the audio (e.g., an intensity time profile) to nearby devices **120** (e.g., using ad hoc wireless communication), which perform local assessments of shooter direction based on the information they obtain.

In yet another scenario, these devices **120** may be used for adaptive crowd control. In situations with high traffic, whether vehicular or pedestrian traffic, these devices **120** may be configured as a mobile ad hoc network to estimate traffic flow from noise, with no requirement for any fixed or embedded sensors. Using the dynamically acquired traffic pattern information, the system **100** may broadcast instructions though the devices **120** or through other means to direct people through paths of lower traffic density, open up different gates or paths, or use sonification or acoustic visualization to alert users to high traffic versus low traffic paths.

A related idea is to create mobile sound-based security systems where the system **100** is able to quickly learn about ambient conditions and sound trends, and use this to signal situations away from normal conditions.

In another use case, these devices **120** may use sentiment detection and emotion detection to identify centroids of trouble in large crowds. A variant of this system **100** can be used to detect user dissatisfaction in their language, or in non-speech audio to alert management to, for example, open more counters in stores.

When users try to meet up with friends in large auditoria or sports stadia, it is often impossible to use mobile phones or to hear conversations on phones. The system **100** may use knowledge of users' social graphs to indicate the presence of friends using directional sonic visualization or sonification, with some variation in tone or volume as users approach their friends. Using the peer to peer architecture of the system **100** along with the knowledge in each device **120** about its neighboring devices **120** and their features, the system **100** can quickly and effectively determine the possible locations of friends. By utilizing the position information, and the orientation information acquired from the user's device **120**, the system **100** can provide differential tones, volumes or other signals to indicate whether the user is moving towards or away from their friends (and whether they are pointed towards or away from their friends), and provide an indication about how far away they are. The precision of this indication may go up with the number of peer devices **120** contributing information to the system **100**.

In another localization use case, a number of devices **120** may be enabled to sense audio, for example, for a group conference call. The locally acquired audio may be used to identify the location of the speaker, and to control which device **120** (or devices **120**) are used to generate the audio for the call. For example, a device **120** closest to the person speaking, or the device **120** providing the highest signal quality or intelligibility, may be selected, thereby providing an improved audio quality.

In another localization use case, devices **120** may be tracked during a shopping trip, for example, in a grocery store or at a mall. The track taken by the user with corresponding audio or video information may be used to identify areas of customer focus and interest, and provide user-specific information, for example, promotional information related to purchase opportunities in the vicinity of the device **120**.

After-the-fact analysis of a track may be used to correlate movement with actual purchases made, or to possible interest in various classes of items. For example, a relatively high time spent in the vicinity of a product type may indicate an interest in that product type. Users may be interested in opting in to having their path tracked in exchange for receiving promotions.

2.3 Topic Monitoring

In another use example, a device **120** may be enabled to monitor the owner's environment as they converse during the day, and as they listen to media broadcasts. Topic detection techniques, for instance, based on spotting topic-related keywords, may be used to assess topics of interest to the user. During the day, or in a periodic summary, the user is presented with collateral information related to the topics. For instance, if the user enters into a conversation about a particular topic, recent news or background material may be offered on the device **120**. Such topic monitoring may also be useful to provide other targeted material to the user, for example, in the form of advertising that is relevant to the user's interests.

The configuration of other devices **120** may be adapted based on what is detected at the user's device **120**. For example, other devices **120** in geographic or social proximity to the user's device **120** may be configured to detect the presence of similar topics. In this way, the other devices **120** may have a higher likelihood of correctly detecting the topics. Furthermore, the controller **120'** or server **140** may be able to track the extent of interest in a topic.

Another topic-related monitoring use may be related to a third party requesting detection of audio signals, such as audio components of advertising to determine where these advertisements have been played. For example, an advertiser may have controller **120'** or server **140** configure devices **120** to detect an advertisement, and then determine where the advertisement has been played and potentially heard.

In a related use case, the system **100** may use information garnered from the sensors of devices **120** and from other sources such as electronic program guides (EPG) to identify what programs users have been listening to or viewing, to get Nielsen-like viewership statistics or to acquire business intelligence. Current systems tend to rely on home systems or manually created diaries, both of which are prone to error. Using exemplary devices **120** and exemplary system **100** may allow for this monitoring to be done wherever the user is, and whatever media device they use, and to use information from user activity to distinguish active listening or viewing from, for instance, a TV playing to an empty room.

2.4 Triggering Events

Generally, use cases described above use various triggering events to begin local logging of audio and/or to initiate communication with the server **140**, device **120'** and/or other nearby devices **120**. In addition to audio-based events (e.g., specific words, spoken topics, music, sounds, etc.), other events may trigger monitoring and/or communication. For instance, content of text communication (e.g., Short Message Service (SMS) messages) may initiate monitoring and/or configure what is to be searched for. Other data, such as accelerometer data, biometric data, and detection of a video image (such as change in luminance, etc.) that is available to the device may also be used in a trigger. For example, high acceleration may be associated with a vehicle accident or a fall, and this may initiate audio monitoring or communication with the server **140** (or device **120'**), which may be able to determine if an accident has occurred based on the audio scene **130**, in which case emergency help may be summoned.

The system **100** may also be used in the care of the elderly and the disabled. Currently senior citizens and the disabled

can purchase a conventional device to signal when they need help, for example if they fall or feel dizzy. However, these conventional systems require the user to consciously make a decision and press a button on the device to ask for help. The problem is that there may be situations where the user cannot make the decision, may be too embarrassed to ask for help, may feel their problem is not critical enough to ask for help, or may not even be able to access the button to call for help. For instance when the user has a stroke or if they have a fall, it may be difficult for an elderly user to press the button. The system **100** described here may use data fusion ideas to combine speech and noise detection from one or more devices **120** along with other accelerometer data to detect calls for help, or sounds from falls, dropped objects, etc., distinguish between false alarms and real problems, and summon help when required as well. System **100** may also be able to turn on the speaker phone to have a dialog with the "help" side of the call.

In another form of triggering event, when a device **120** is removed from the direct acoustic environment, for example, by being put in a user's pocket, the change in audio signal characteristics may trigger a message to the controller **120'** or server **140** to indicate that the device **120** is no longer available for acquiring audio based on a poor signal-to-noise ratio (SNR) operating environment. Similarly, when the device **120** is taken out of the pocket, it may again start monitoring the environment and/of notify the controller **120'** (or server **140**) that it is once again available. In addition, when the device is no longer obtaining adequate SNR, the device **120** may be able to enable other devices **120** within its proximity to acquire the signal and thus improve the overall SNR. In addition, many devices are now manufactured with multiple microphones (primarily used for beam forming) as to obtain an improved SNR for the user. As the user may often carry the device **120** in their pocket or purse, system **100** may be able to select which microphone in the device **120** is desirably enabled or what beam forming array would be best evoked to obtain a maximum SNR.

In some examples, vehicle texting is disabled by the system **100**. By detecting an acceleration signature consistent with being in a moving vehicle and/or by picking up the type of sounds picked up while driving, the device **120** can detect road noise, the engine noise, wheel bearing noise, breaking noise All of these sounds may be used to either disable or enable the user from utilizing their device **120** for texting while the car is in motion. The device **120** may query its proximity and determine if other devices **120** were present within the body of the automobile. Assuming the answer were yes, further analysis may be used to provide limitations on the driver's device **120** from texting while still allowing the balance of the individuals to text. Some cars also disable or limit select navigational controls for safety reasons when the car is in motion. If the device **120** is able to detect a front seat passenger, the system may choose not to limit navigational controls.

In some examples, key word spotting obtained from in-situ conversations is aggregated from both the sender and recipient. During the course of normal telephone conversations, the device **120** may identify specific sounds, words, etc being uttered by both parties of a conversation. The system **100** may interrogate these sounds and provide the user with information either thru a graphical user interface (GUI), or audio based or text based feedback. As an example, assuming a call was about a trip to Paris, the device **120** could render information about promotional pricing on an airline to Paris.

One or more of these devices **120** may be used to identify trends in audio and other information acquired by these devices **120**, for example using keyword spotting in audio streams. Keyword trends may be used to adaptively mediate or modify information consumed by users. In one scenario, information sources such as news media, search engines and similar information outlets may acquire information on trends from individual users or groups of users, and show different items to different users based on keyword trending. Specifically such a system **100** may choose topics users have been known to prefer.

Trending on non-speech audio may be used to identify patterns of people flow or vehicular flow. Aggregated logs of speech and non-speech audio may be used for a number of diverse applications, including identifying less noisy apartments or houses to rent or buy and areas of hotels or theater halls that may be better soundproofed. Longer term trending and identification of trends and periodic variations may be used for soundproofing or weatherproofing offices and residences.

2.5 Other Aspects and Uses

The ability to aggregate information over many smartphones can be provided with or without the cooperation of the carriers. It could be done, for example, with a third party application, which doesn't need the approval of a particular carrier and communicates via Wi-Fi or Bluetooth.RTM. In this way, information can be aggregated across phones serviced by multiple competing carriers.

In some exemplary embodiments of the system **100**, the system **100** may trigger off key events such as rapid deceleration of several cars at the same time and place, sirens, keywords, etc. The ability to collect vast quantities of data may improve the triggering capability. Search companies are providing better search relevancy than ever before, largely because they are collecting more data than was possible before, the popularity of modern search engines. But with the exemplary system **100**, it may become possible to collect even more data. If every phone were collecting audio data for an hour a day, the aggregate data resource would be much larger and much more valuable than the data collections currently collected by even the largest search companies.

In some exemplary embodiments of the system **100**, if a device **120** in the system **100** may detect certain important keywords and phrases like "fire," then the system **100** may respond appropriately. The importance and urgency of a term depends both on the consequences of inaction as well as term weighting concepts that are well known in the field of Information Retrieval.

Similarly, if a system **100** hears an important term (such as a keyword like "fire" or a non-word like a cough or an event picked up on some other sensor of device **120** such as a rapid deceleration), then the system may turn on numerous other nearby sensors in the array to confirm the event, to improve the signal to noise ratio and/or to localize the event in time and space.

In some uses, trending analysis may use the large amount of data available through the system **100**. Consider the cough example mentioned above. Aggregations of coughs over time and space may provide tracking of health over time and space. The approach is similar some approaches to prediction of the flu based on queries where they showed that they could predict flu a couple of weeks faster than the Centers for Disease Control and Prevention (CDC). But the proposed cough metric should have even better resolution over time and space since it is based on a larger quantity of sensed data.

Collection of large amounts of sensed data provides a way to systematically predict (e.g., according to a statistical model) sequences or sets of sensed events of other information. Such prediction may effectively be exploited based on principles related to Shannon's Noisy Channel Model, for example, to improve transmission capacity for such events. For example, such data can allow one to create a better "language model" for events, which will do a better job of predicting what sounds to expect to hear (the prior for the noisy channel model) as well as sounds that are anonymous (triggers that should sound alarms and start recording).

In some examples, workplace monitoring (and monitoring of the environment) may be enabled by the system **100**. The system **100** may effectively provide "smartdust" on smartphones, which is able to monitor workplaces for health issues by measuring acoustical events like coughs. Moreover, in some uses, the system **100** may sense correlates of stress such as noise. Some call centers, for example, have more stress related illnesses because the call volume has relatively large numbers of unhappy customers. It may be possible to predict risk of certain types of illnesses well before symptoms develop, both at work as well as elsewhere.

An ad hoc network of devices **120** may be used to fine-tune a number of features. Consider concert-hall acoustics, for instance. Concert halls are typically tuned for the major uses of their space. For example, a symphony hall may be tuned especially for a large group of artistes and their instruments, and may not be as well suited to, for example, solo vocalists. Sound quality in a hall is also dependent on the size of the audience, their ambient noise characteristics etc. The network of system **100** may enable data to be acquired from a large number of devices **120** in the audience, so that the hall management can adapt to the ambient noise levels and fine-tune sound levels for any performance, with any number of performers and instruments, and with different audiences.

The ad hoc network can also be used for monitoring and regulatory purposes. Sound pressure levels or similar measures of rock concerts, gym classes and other potentially noisy environments may be monitored against safe listening levels, and infractions reported to the appropriate management or regulatory agency.

A similar scheme may be used to fine-tune the temperature in large auditoria, rooms or halls, based on data acquired from a number of devices **120** and individual sensors in that space. Large spaces have their own airflow and heating and cooling patterns, based on placement of air ducts, windows, doors and other openings. Heating and cooling is typically based on measuring temperature in one and occasionally more sensing locations. If the sensor is near a sunny window or a draft caused by a constantly open door, the temperature in that space can be unsatisfactory. By measuring temperature in several locations using a set of devices **120** as described in this invention, it will be possible to have finer, more localized control of temperature.

Some exemplary embodiments of the system **100** may make predictions based on a small sample of "opt ins." The system **100** (e.g., "cloud") may be equipped with appropriate logic to determine how to make appropriate inferences based on information gathered from those phones **120** that choose to opt into the system **100**. Many of these inferences are relatively straightforward, though care may need to be taken to account for the fact that the sample is not a random sample. The set of people that own a smartphone and choose to participate will be skewed toward certain demographics, at least in the near term.

3 Backup Communication Uses

In some versions of the system, the mesh-like features of the set of personal devices **120** may be exploited. Cell phones may be viewed as relatively passive (receive only) devices, but there are times, such as during an emergency, where it could be desirable to be able to deploy an active communication network very quickly as an overlay to more traditional telephone and internet networks.

During an emergency such as a man-made event like September 11 or a natural disaster such as a major hurricane, it is possible that parts of key communication infrastructures could be down.

There was a time when telecommunication networks were much more protected than they are these days. The telephone network used to be more reliable than the power grid. Central offices are typically backed up with batteries and generators (and submarine doors in places like New Orleans that are subject to flooding). Plain old telephone service (POTS) handsets used to be powered from the central office, so the service could stay up even if the standard power grid was down.

These days, most handsets sold in popular stores depend on the power grid. Most phones have lots of features and a power cord. Some have battery backup, but there is little incentive to replace the battery. Soon, the battery backup feature may be a thing of the past because many people aren't willing to pay for such features. Engineers like to design bridges for the hundred years' flood, but it is hard to persuade customers to pay for features they probably won't use. Given these realities, it is desirable to develop a way to deploy a backup network just-in-time. Unlike batteries and generators, which are expensive whether we use them or not, a backup network based on phones typically won't cost the public much if any additional capital, because most of the equipment is already in place.

Key features of a backup network:

1. Two-way communication: Telephone receivers normally receive but they can also be used to store and forward information. Thus for example, if a phone was on a mobile platform (say in a pocket or in a car), then the phone could be used in sneakernet mode to store a signal in one place and repeat it from another place.

2. Damage Assessment (the ability to determine quickly and easily what is working and what is not): During September 11, there were many outages (e.g., fiber cuts under #7 World Trade Center, cell towers on the rooftops, switches under both #1 and #2 World Trade Center, police and fire radio communication in certain places), but some things were working (e.g., cell towers in New Jersey, BlackBerry™ email, systems based on satellites). A key requirement is to determine what is working and what is not, and to communicate workarounds to those that need them. An array of cell phones in a multitude of pockets and cars could determine fairly quickly what is working and what is not. Hopefully, some of these devices may be connected to something that is working (such as a satellite) or would eventually move out of the affected area so enough of them could report an accurate and timely damage assessment picture back to the cloud. Using this information, both digital and real world traffic may be adaptively rerouted.

3. Workarounds: Municipal vehicles such as buses have batteries and generators. Soon, such vehicles may also have Wi-Fi that is connected to satellites. The cloud could direct such resources where they are needed most.

An acoustical array, such as what is described herein, may also be used in damage assessment. For example, the acoustical array may determine both whether there is too

much noise (e.g., explosions) as well as too little noise (e.g., absence of human activity), aggregated over time and space.

4 Authorization and Privacy

In some exemplary embodiments of the system **100**, privacy considerations may be addressed using one or more features, which may include the following. First, monitoring may be enabled on a device **120** only if the user explicitly "opts in" to permit particular monitoring options. A reason that a user may accept such monitoring is that he, in return, obtains information that is valuable to him, for example, by being provided more relevant search results or other information. Another feature relates to encryption of the monitored information. For example, audio may be encrypted in a manner than prevents interception during uploading and/or processing by a controller **120'** or server **140**. Furthermore, in systems **100** in which multiple central controllers are used (e.g., one controller **120'** or server **140** per cellular telephone carrier), the user may explicitly permit sharing between or among controllers.

In some examples, devices **120** may have features that inhibit collection of audio environment data. Such features may be mechanical (for example, mechanically preventing audio pickup with a shutter mechanism) or can be electronic (for example, with an electronic slider switch on the device).

In some examples, sensors can be selectively turned on or off both at the edge of the network (in the smartphone), as well as in the network (in the cloud), as well as elsewhere. For example, the operator of a movie theatre may have the ability to turn off speakers that would annoy others in the movie theatre, and similarly the operator of an airplane should have the ability to turn off communication features that could jeopardize the safety of fellow passengers. Moreover, after an incident, such as a plane accident, the authorities should have the ability to probe (via a wired or wireless interface to the memory of the phone-could be non-volatile) the smartphones on the plane for information that could be helpful in the investigation. In other words, the array of smartphones on the plane could serve as a kind of "black box" to prevent similar such incidents in the future.

However, privacy is also important in at least some versions of the system **100**. In some exemplary embodiments, the owner of the smartphone should have the ability to pull the curtain with confidence that the phone is not invading the user's privacy, even if the phone has been taken over by a virus. When the curtain is pulled, the user wants to be sure that the phone is not recording information that could be embarrassing or self-incriminating. The phone should not be recording information that could be subject to subpoena or a court order such as discovery. The user should have the ability to opt out in a way that cannot be overridden by the owner of the network, government authority, or anyone else (such as a malicious hacker). For example, privacy may be implemented by a switch, as described further below.

Feature interaction can be a tricky problem in a communication network. While it is desirable that many parties have the ability to turn on and off certain features in certain ways, as discussed above, it is also important that it be clear to all parties what happens when different parties issue commands that may conflict with one another in complicated and unanticipated ways.

In particular, in at least some exemplary embodiments of the system, the owner of the phone ought to be in charge. In such embodiments, the owner may have the ability to physically disconnect the sensors in a way that cannot be overruled by any other party. One such method may include a physical switch that would disconnect the sensors in a way that the user can verify by visual inspection of the phone. The physical switch may be operated manually by the user and cannot be overridden remotely under software control.

In addition to the physical switch, there may also be a software controlled switch that may empower authorized parties to turn on and off features such as recording of sensors, recognizing keywords and uploading appropriate information to the cloud where inferences can be made that aggregate over space and time. Policies may eventually be determined regarding who is allowed to do what, and what is appropriate and what is not.

5 Other Devices

As introduced above, the exemplary approaches described above are not limited to smartphones. For example, in-vehicle systems (e.g., navigation devices), media devices (e.g., televisions, set-top boxes, desktop computers, laptop computers), and other fixed or mobile devices may be used in similar ways. For example, in the case of an in-vehicle navigation system, an in-vehicle conversation may be monitored and information about a location (e.g., a restaurant) that is being discussed may be provided on the device's display.

Another type of device that may be used in such a system is an earpiece that provides audio input and output for a telephone (device). An advantage of monitoring with the earpiece is that it is exposed to the acoustic environment even when the associated phone is not exposed to the environment, for example, when the phone is in a user's pocket, thereby providing an improved signal-to-noise ratio (SNR). Another embodiment may have the entire mobile communication (cell phone) being integrated into the earpiece.

Another type of device **120** that may be used in such a system **100** is a hearing aid. The hearing aid may allow the entire feature set thus described in herein to be made practical. The advantage of this is data which could be mined from this age population is thought to be very different for the generation of users who typically use headphones for their communication activities.

Use of earpieces as described above can be thought of as ownership or control of the "last inch," which is similar to the ownership of the "last mile," which has been strategically important in the telephone business. The same dynamic underlies the debate over net neutrality. So too, ownership over the last inch will become strategically important in the war over eyes and ears.

The web is currently about eyeballs and mouse clicks, but soon the war will move to a struggle for access to ears as well as eyes. The hearing aid or earpiece could be viewed as a chief of staff. It gets to decide what the user hears and what the user doesn't hear. The hearing aid could give the wife preferred access. It could also block spam, and filter out unwanted commercials. Alternatively, the hearing aid or earpiece could run an auction similar to a paid search, where the hearing aid is a market maker that attempts to find an equilibrium between the need of the user for relevance and utility to the advertiser.

These auctions typically use a Vickrey auction to encourage advertisers to bid their true utility. If the user chooses to follow up on an ad (with a mouse click), then the advertiser pays the second highest bid. The hearing aid or earpiece could work in a similar way though, perhaps, instead of clicking on an ad, it might be easier for the user to participate by some other means such as a spoken command.

Although the invention has been described in terms of systems and methods for processing information from a plurality of distributed devices, it is contemplated that one or

more steps and/or components may be implemented in software for use with microprocessors/general purpose computers (not shown). In this embodiment, one or more of the functions of the various components and/or steps described above may be implemented in software that controls a computer. The software may be embodied in non-transitory tangible computer readable media (such as, by way of non-limiting example, a magnetic disk, optical disk, flash memory, hard drive, etc.) for execution by the computer.

For example, some of the software may include instructions for execution at the personal devices **120** and device **120'**. This software may be stored on a non-transitory tangible computer readable medium at a central location, for example, at a server **140** for distribution to the devices **120**, **120'**, may be transferred over a digital communication medium, and/or stored in a machine readable medium at the devices **120**, **120'** (e.g., as downloaded applications/applets). Some of the software may be hosted at central servers **140** (e.g., in a distributed "cloud" of processors) and made accessible by storing it on non-transitory tangible computer-readable media for execution on processors of the servers **140**.

Although the invention is illustrated and described herein with reference to specific embodiments, the invention is not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope and range of equivalents of the claims and without departing from the invention.

I claim:

1. A system comprising:

a device among a plurality of acoustic devices; wherein the device is configured as a controller, wherein the controller is configured to perform operations comprising:

selecting a subset of acoustic devices from among the plurality of acoustic devices for acquiring sensor acoustic data, wherein the subset of acoustic devices are configured to interchange device information and data over a communication link;

receiving a first set of sensor acoustic data from a first acoustic device of the selected subset of acoustic devices;

receiving a second set of sensor acoustic data from a second acoustic device of the selected subset of acoustic devices; and

analyzing at least one of the first set of sensor acoustic data or the second set of sensor acoustic data or a combination of both to identify if speech is present.

2. The system according to claim **1**, wherein the operations further comprise:

analyzing the speech for a keyword.

3. The system of claim **2**, wherein the first set of sensor acoustic data and the second set of sensor acoustic data are received based on a triggering event.

4. The system of claim **3**, wherein the operations further comprise:

determining a direction of measurement of at least one device of the subset of devices.

5. The system of claim **1**, wherein the operations further comprise:

selecting the subset of devices based on geographic proximity to a user.

6. The system of claim **2**, wherein the operations further comprise:

activating a sensor based upon the keyword.

7. The system of claim **1**, wherein the operations further comprise:

generating an alert signal based upon an analysis of at least one of the first set of acoustic sensor data or the second set of acoustic data or a combination of both.

8. The system of claim **1**, wherein the operations further comprise:

analyzing at least one of the first set of acoustic sensor data or the second set of acoustic sensor data or a combination of both for animal sounds.

9. The system of claim **1**, wherein the operations further comprise:

determining the locations of each of the selected subset of acoustic devices.

10. The system of claim **2**, wherein the operations further comprise:

determining which of the selected subset of acoustic devices is the closest acoustic device to a user that uttered the keyword.

11. The system of claim **10**, where the operations further comprise:

determining a voice command from the keyword; and

sending the voice command to the closest acoustic device.

* * * * *

EXHIBIT C

US011610587B2

(12) **United States Patent**
Goldstein et al.

(10) **Patent No.: US 11,610,587 B2**
(45) **Date of Patent: Mar. 21, 2023**

(54) **PERSONALIZED SOUND MANAGEMENT AND METHOD**

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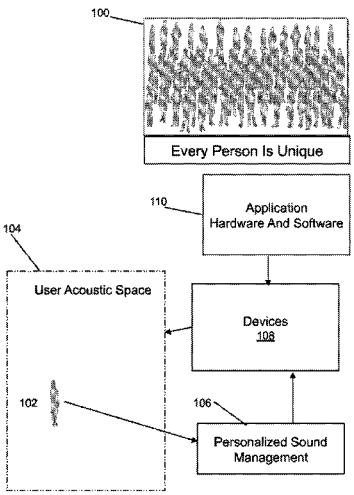
(57) **ABSTRACT**

A personalized sound management system for an acoustic space includes at least one transducer, a data communication system, one or more processors operatively coupled to the data communication system and the at least one transducer, and a medium coupled to the one or more processors. The processors access a database of sonic signatures and display a plurality of personalized sound management applications that perform at least one or more tasks among identifying a sonic signature, calculating a sound pressure level, storing metadata related to a sonic signature, monitoring sound pressure level dosage levels, switching to an ear canal microphone in a noisy environment, recording a user's voice, storing the user's voice in a memory of an earpiece device, or storing the user's voice in a memory of a server system, or converting received text received in texts or emails to voice using text to speech conversion. Other embodiments are disclosed.

12 Claims, 15 Drawing Sheets



Related U.S. Application Data

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PCT Written Opinion for PCT Applicaiton No. PCTIUS07/85134 dated Jun. 12, 2008.
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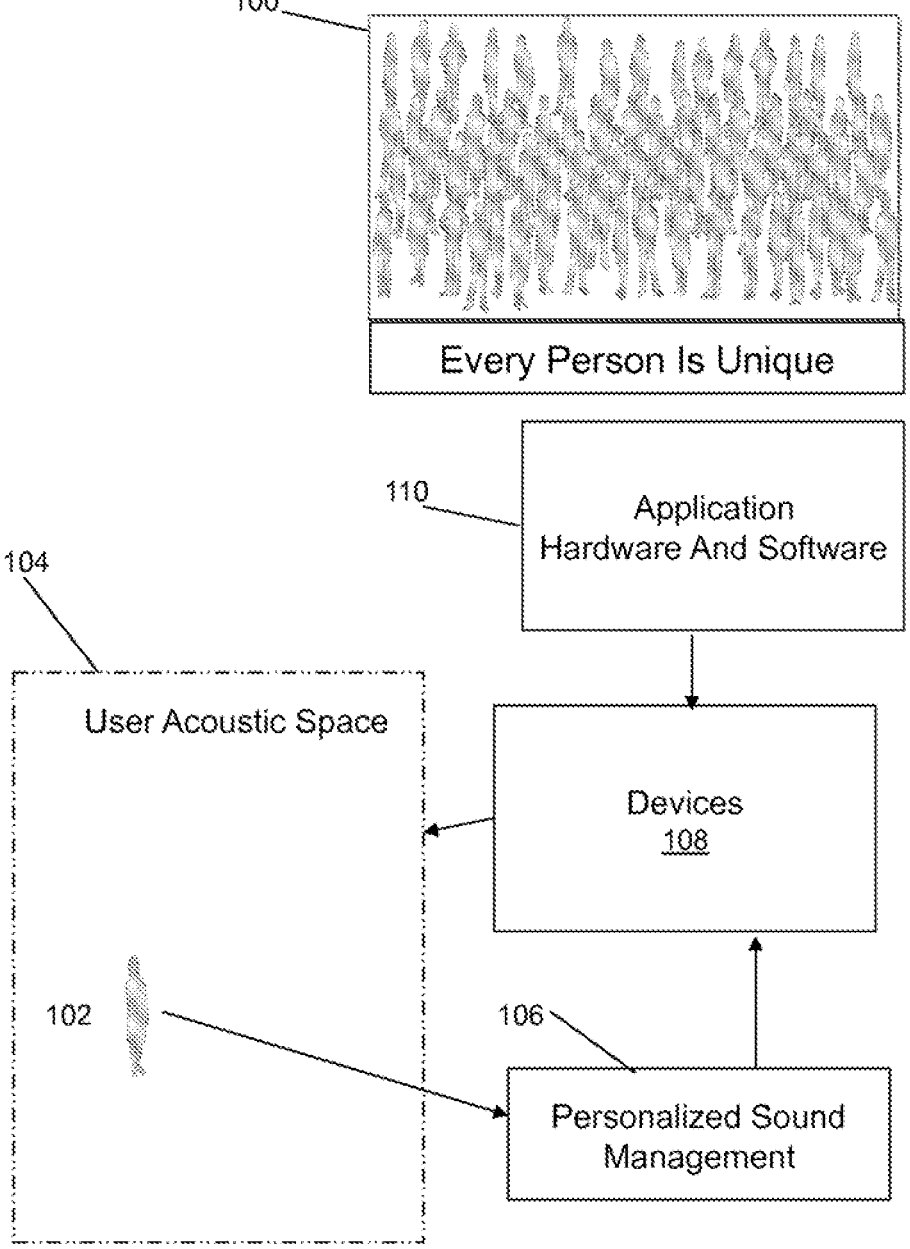
Patent Cooperation Treaty, "International Search Report," issued in International Patent Application No. PCT!US09/57751, by U.S. Search Authority dated Nov. 6, 2009 document of 2 pages.

* cited by examiner

FIG. 1


100
Every Person Is Unique
110
Application
Hardware And Software
104
User Acoustic Space
Devices
108
102
106
Personalized Sound
Management

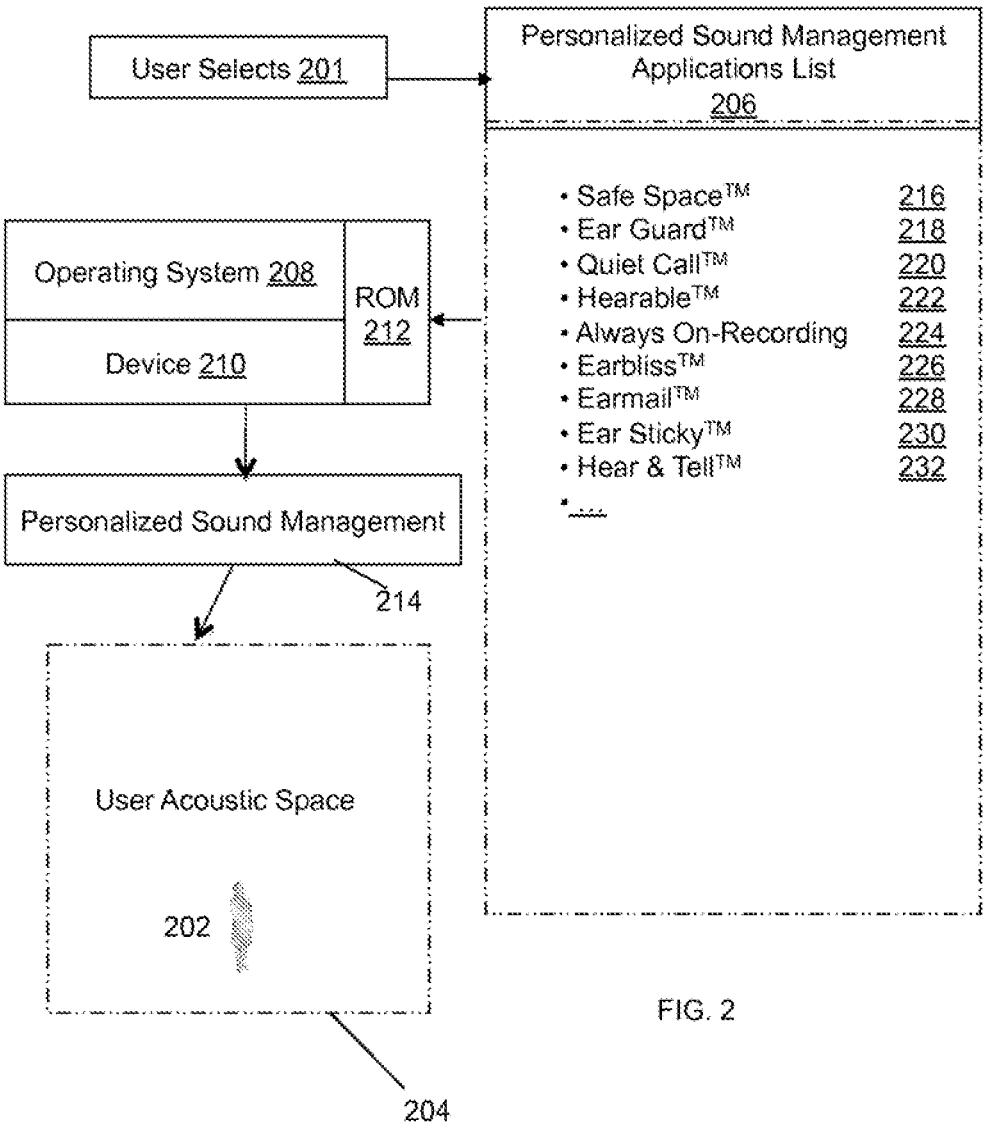

User Selects 201
Personalized Sound Management Applications List 206
• Safe Space™ 216
• Ear Guard™ 218
• Quiet Call™ 220
• Hearable™ 222
• Always On-Recording 224
• Earbliss™ 226
• Earmail™ 228
• Ear Sticky™ 230
• Hear & Tell™ 232
• ....
Operating System 208
Device 210
ROM 212
Personalized Sound Management
214
User Acoustic Space
202
204

FIG. 2

FIG. 3

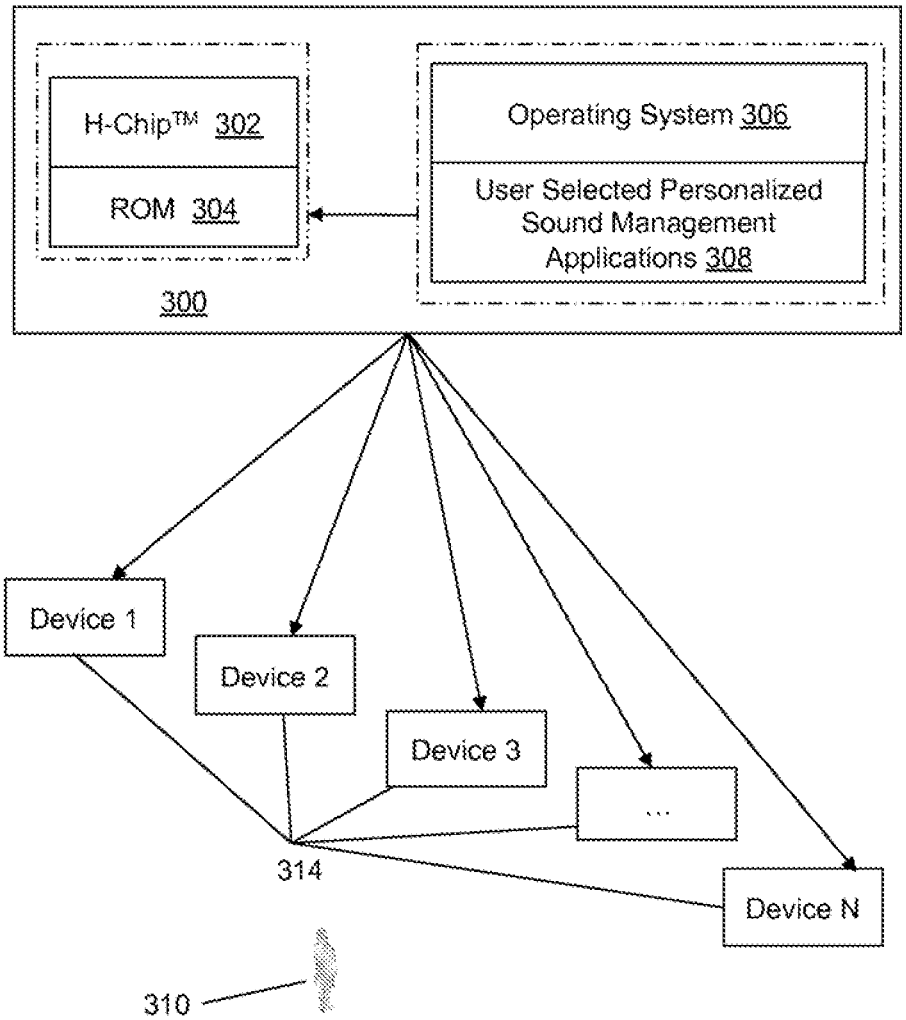

H-Chip™ 302
ROM 304
300
Operating System 306
User Selected Personalized Sound Management Applications 308
Device 1
Device 2
Device 3
...
Device N
314
310

FIG. 4

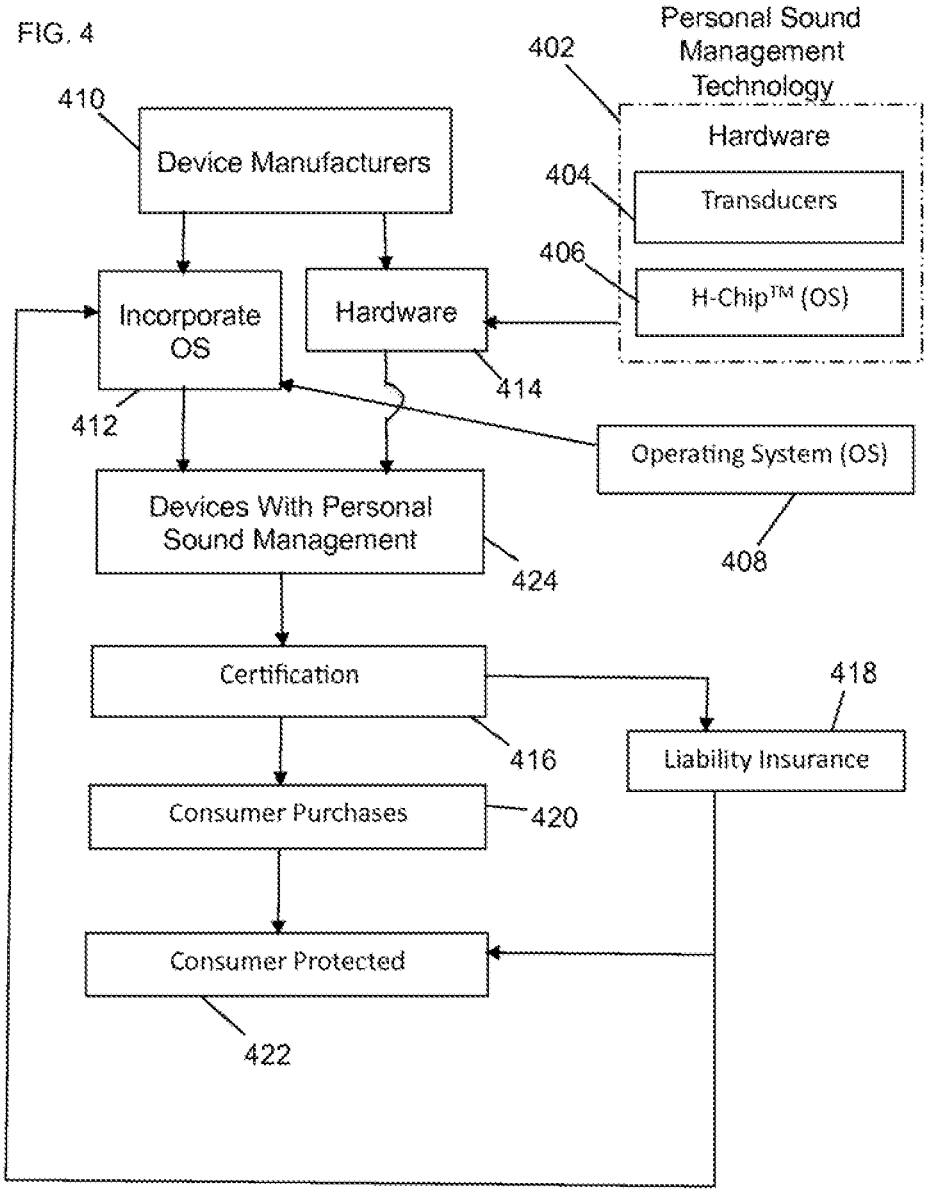
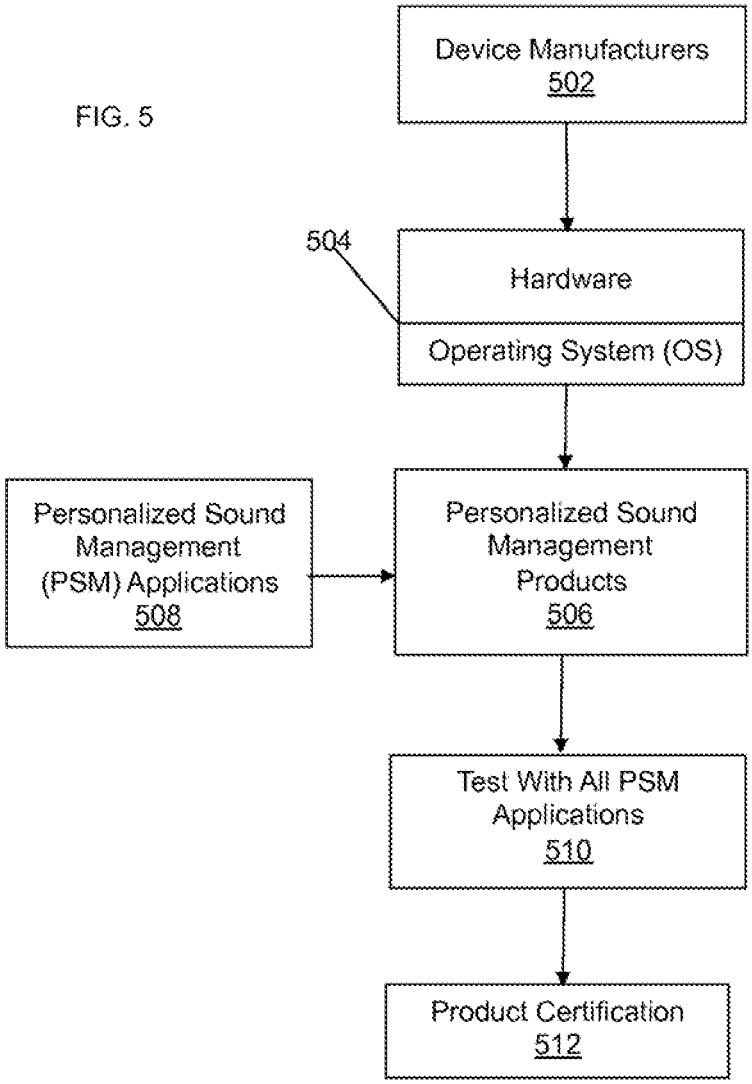

Personal Sound Management Technology
402
Hardware
404
Transducers
406
H-Chip™ (OS)
410
Device Manufacturers
Incorporate OS
Hardware
414
412
Operating System (OS)
408
Devices With Personal Sound Management
424
Certification
418
416
Liability Insurance
Consumer Purchases
420
Consumer Protected
422

FIG. 5


Device Manufacturers
502
504
Hardware
Operating System (OS)
Personalized Sound Management (PSM) Applications
508
Personalized Sound Management Products
506
Test With All PSM Applications
510
Product Certification
512

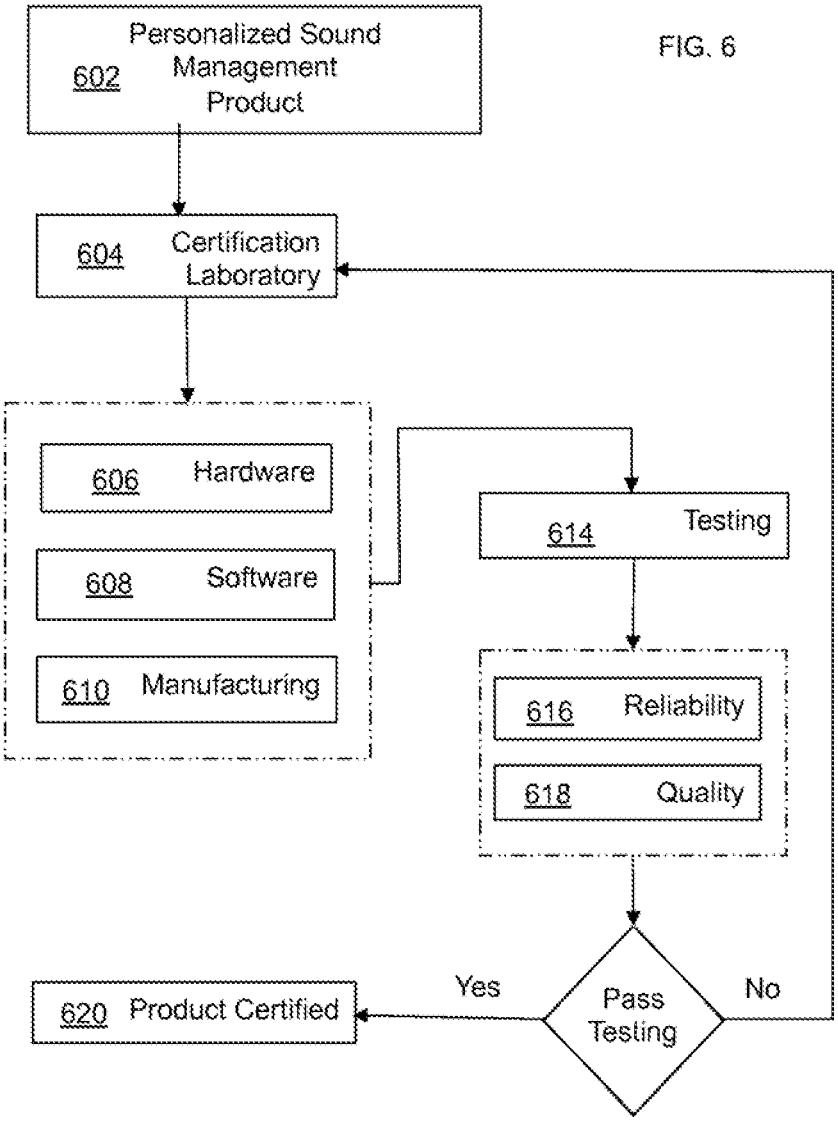
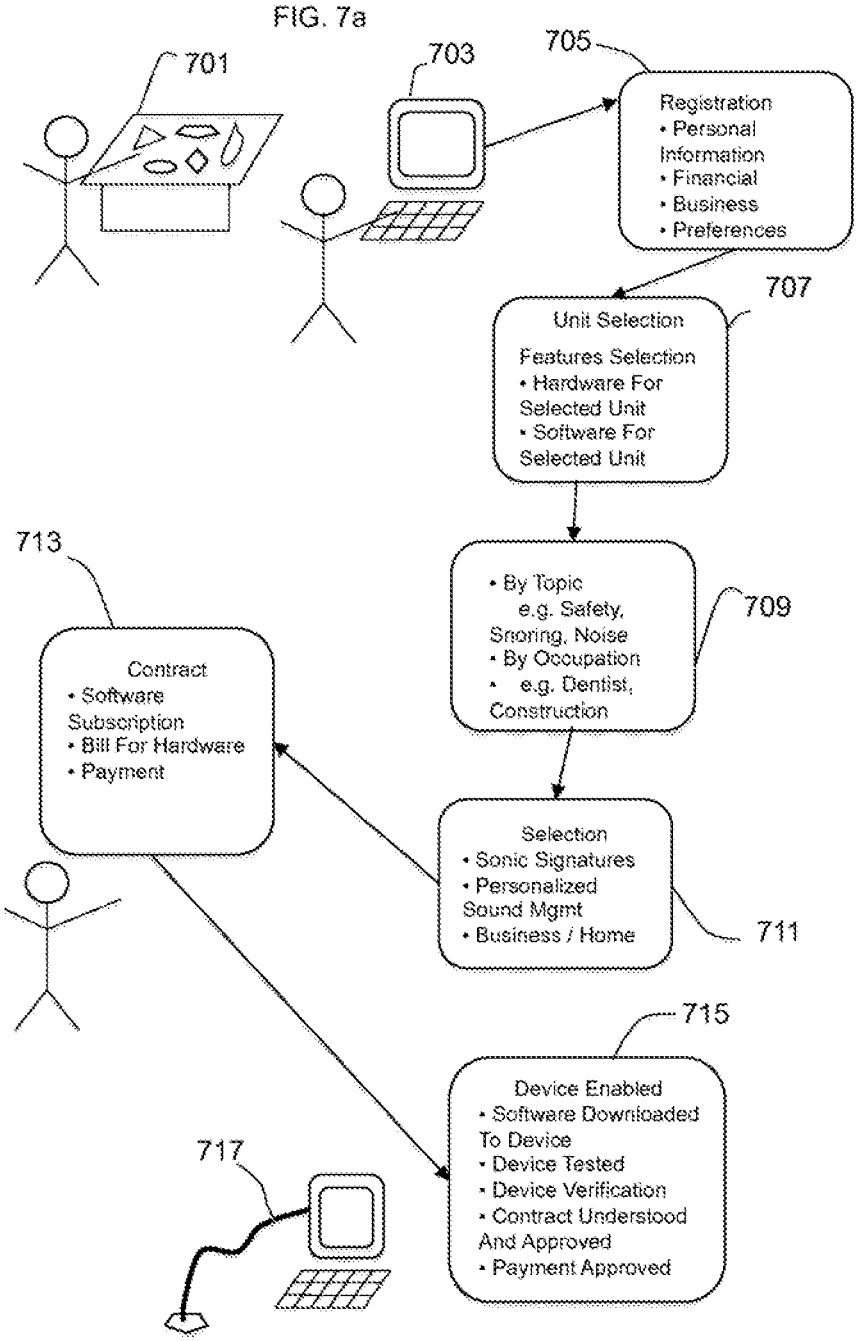

Personalized Sound Management Product
602
604
Certification Laboratory
606
Hardware
608
Software
610
Manufacturing
614
Testing
616
Reliability
618
Quality
Pass Testing
Yes
No
620
Product Certified

FIG. 6

FIG. 7a


701
703
705
Registration
• Personal Information
• Financial
• Business
• Preferences
707
Unit Selection
Features Selection
• Hardware For Selected Unit
• Software For Selected Unit
713
• By Topic
e.g. Safety, Snoring, Noise
• By Occupation
• e.g. Dentist, Construction
709
Contract
• Software Subscription
• Bill For Hardware
• Payment
Selection
• Sonic Signatures
• Personalized Sound Mgmt
• Business / Home
711
715
Device Enabled
• Software Downloaded To Device
• Device Tested
• Device Verification
• Contract Understood And Approved
• Payment Approved
717

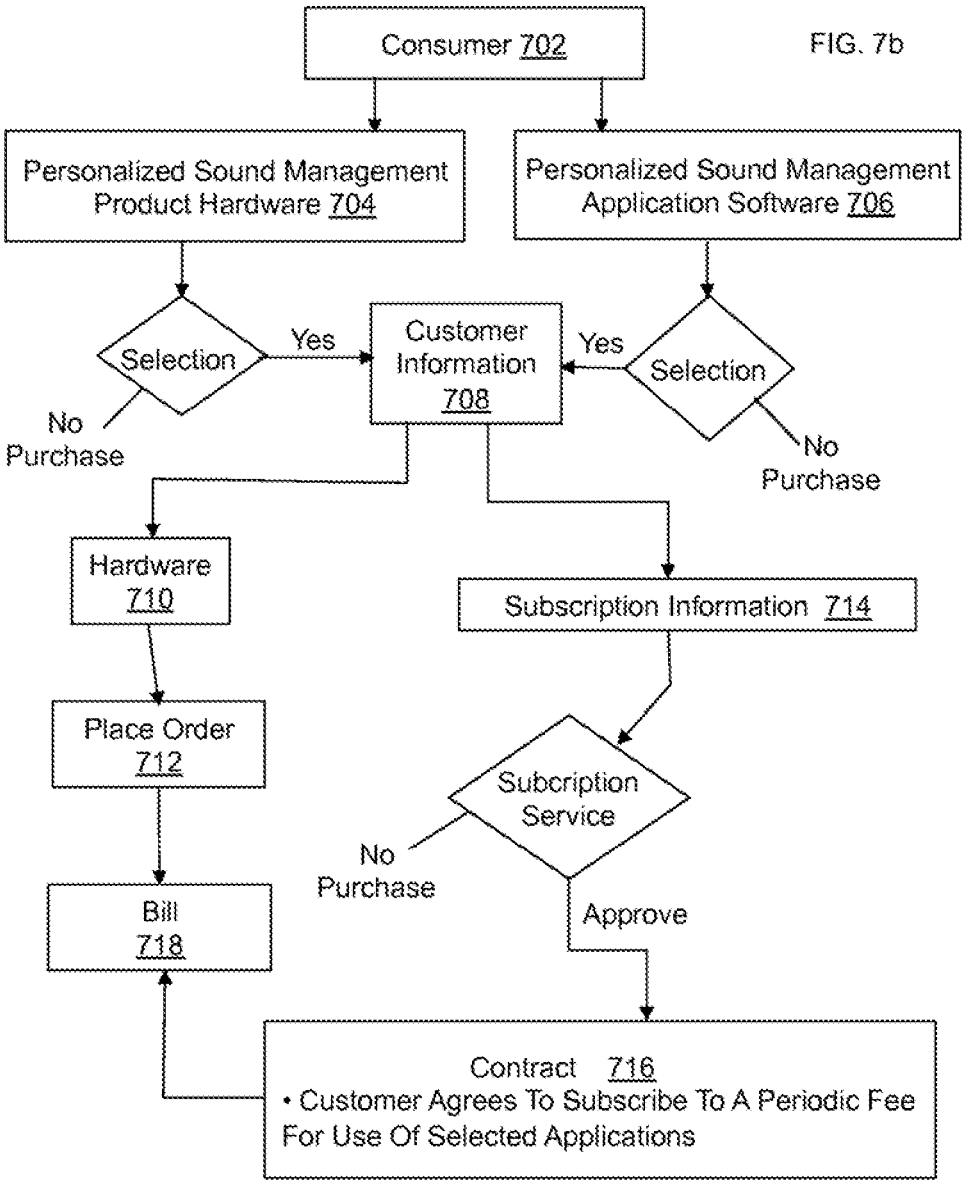

Consumer 702
Personalized Sound Management Product Hardware 704
Personalized Sound Management Application Software 706
Selection
Yes
No Purchase
Customer Information 708
Yes
Selection
No Purchase
Hardware 710
Subscription Information 714
Place Order 712
Subcription Service
No Purchase
Approve
Bill 718
Contract 716
• Customer Agrees To Subscribe To A Periodic Fee For Use Of Selected Applications

FIG. 7b

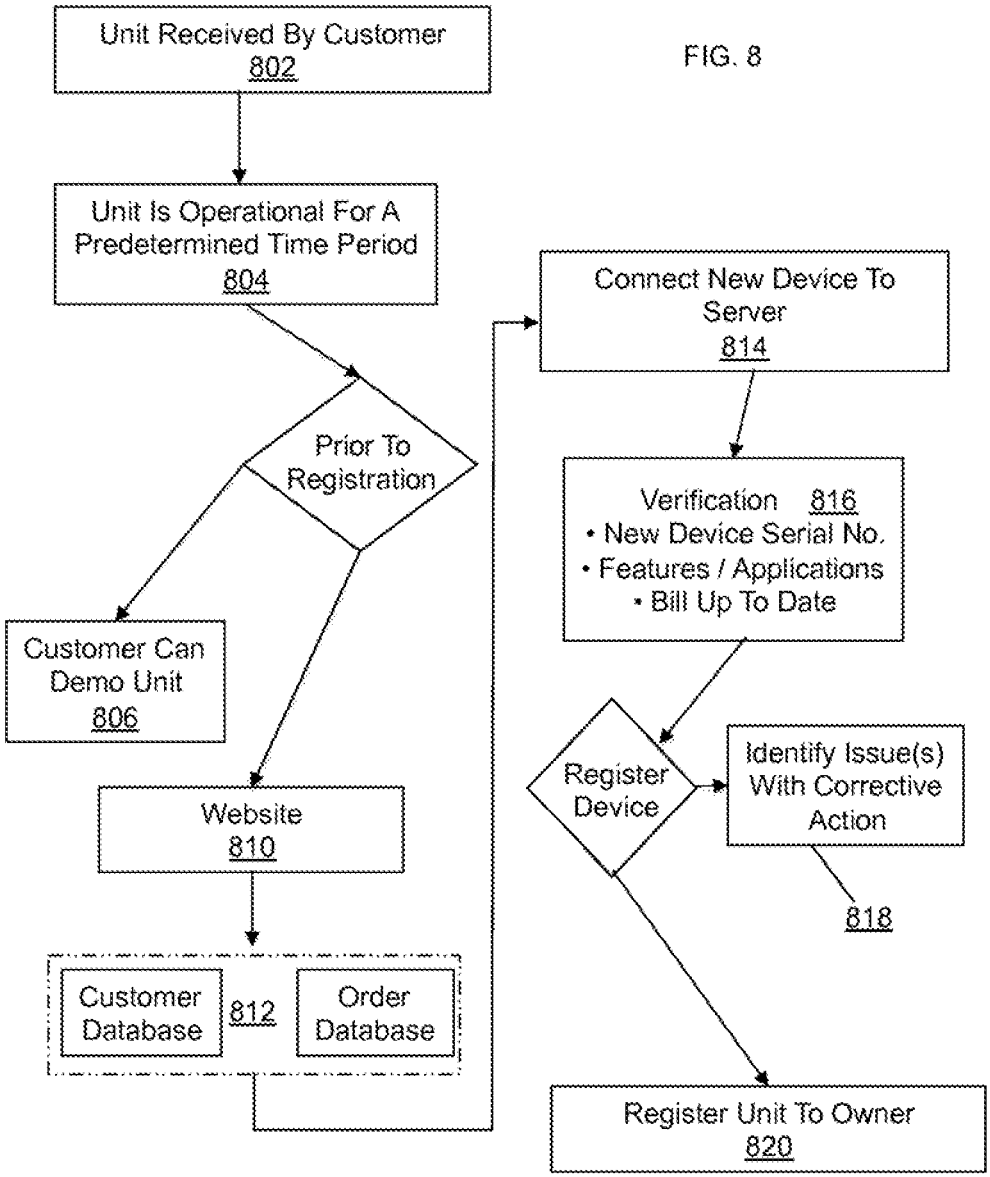
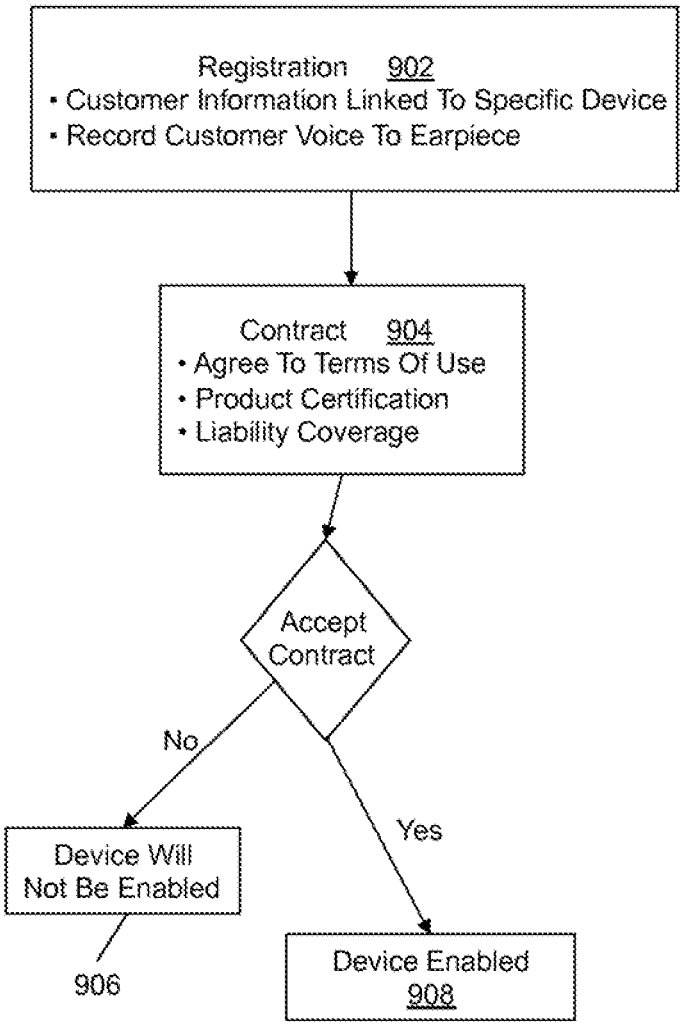

Unit Received By Customer
802
Unit Is Operational For A Predetermined Time Period
804
Prior To Registration
Customer Can Demo Unit
806
Website
810
Customer Database
812
Order Database
Connect New Device To Server
814
Verification 816
• New Device Serial No.
• Features / Applications
• Bill Up To Date
Register Device
Identify Issue(s) With Corrective Action
818
Register Unit To Owner
820

FIG. 8

FIG. 9


Registration 902
• Customer Information Linked To Specific Device
• Record Customer Voice To Earpiece
Contract 904
• Agree To Terms Of Use
• Product Certification
• Liability Coverage
Accept Contract
No
Yes
Device Will Not Be Enabled
906
Device Enabled 908

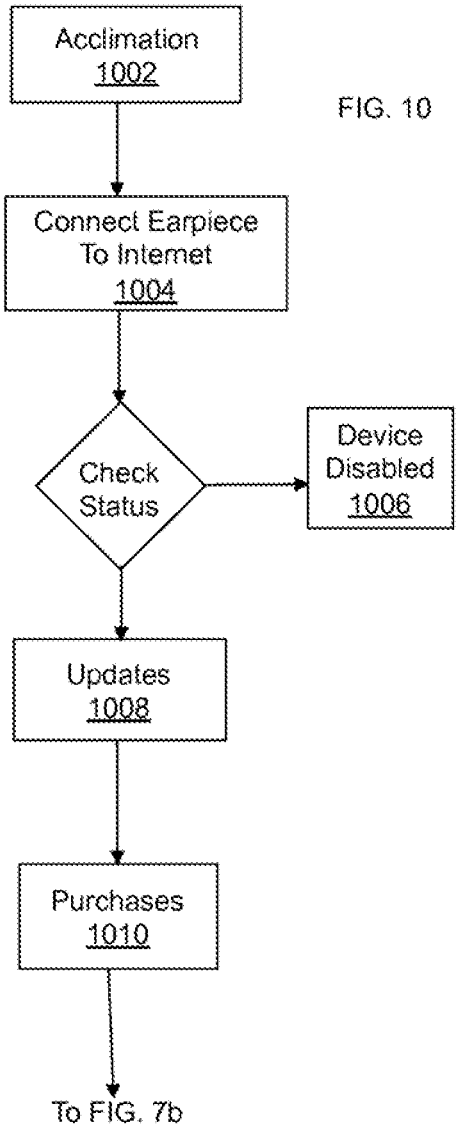

Acclimation
1002
Connect Earpiece
To Internet
1004
Check
Status
Device
Disabled
1006
Updates
1008
Purchases
1010
To FIG. 7b

FIG. 10

FIG. 11

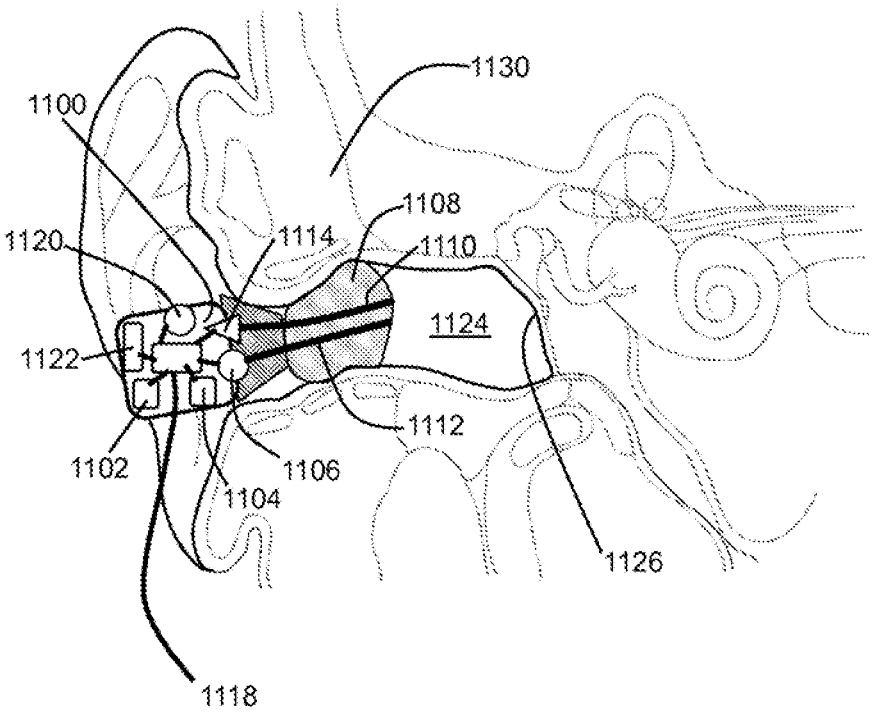

1130
1100
1108
1120
1114
1110
1124
1122
1112
1102
1106
1104
1126
1118

FIG. 12

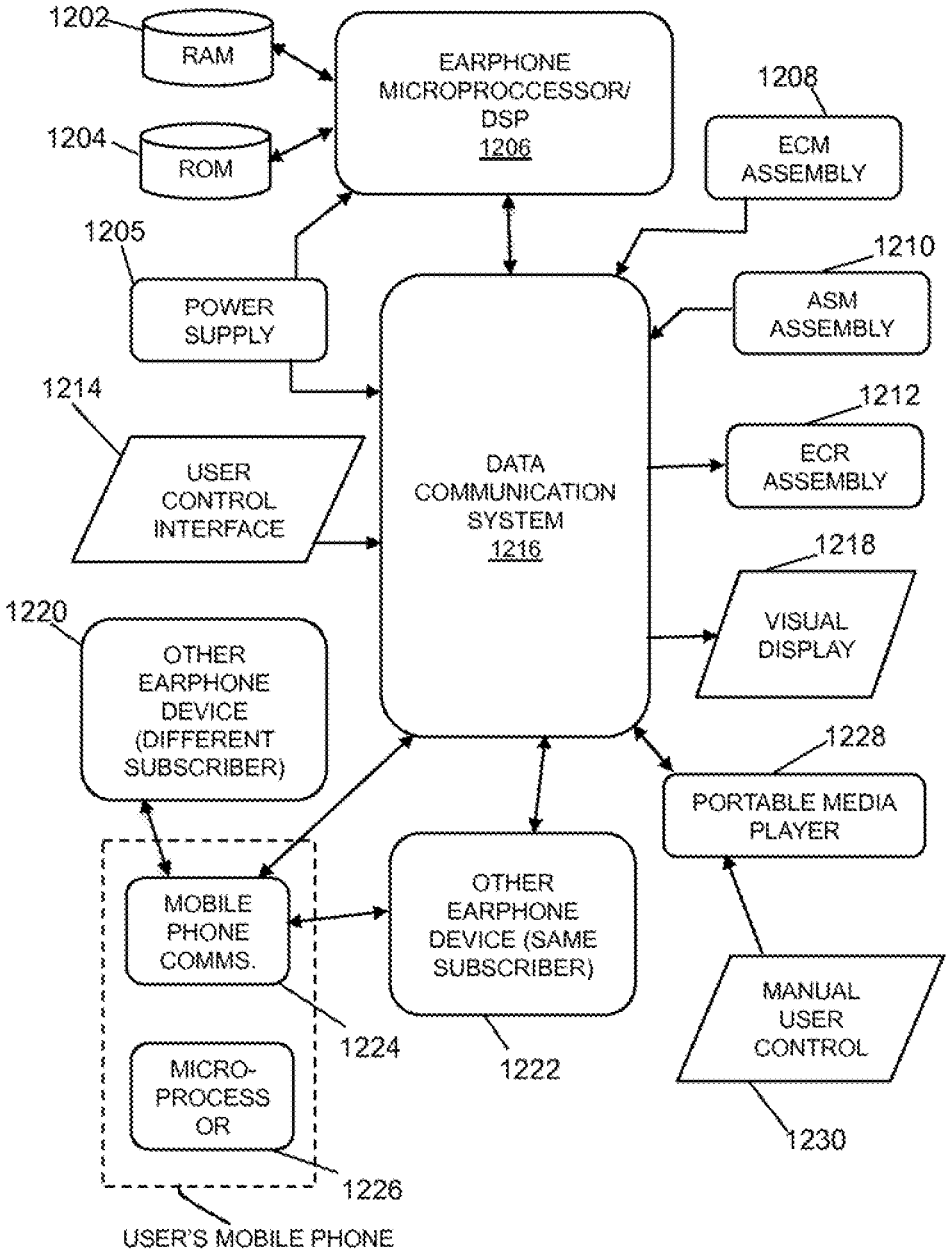

1202
RAM
1204
ROM
EARPHONE MICROPROCCESSOR/ DSP 1206
1208
ECM ASSEMBLY
1205
POWER SUPPLY
1210
ASM ASSEMBLY
1214
USER CONTROL INTERFACE
DATA COMMUNICATION SYSTEM 1216
1212
ECR ASSEMBLY
1218
VISUAL DISPLAY
1220
OTHER EARPHONE DEVICE (DIFFERENT SUBSCRIBER)
1228
PORTABLE MEDIA PLAYER
MOBILE PHONE COMMS.
OTHER EARPHONE DEVICE (SAME SUBSCRIBER)
MANUAL USER CONTROL
1224
1222
MICRO-PROCESS OR
1230
1226
USER'S MOBILE PHONE

FIG. 13

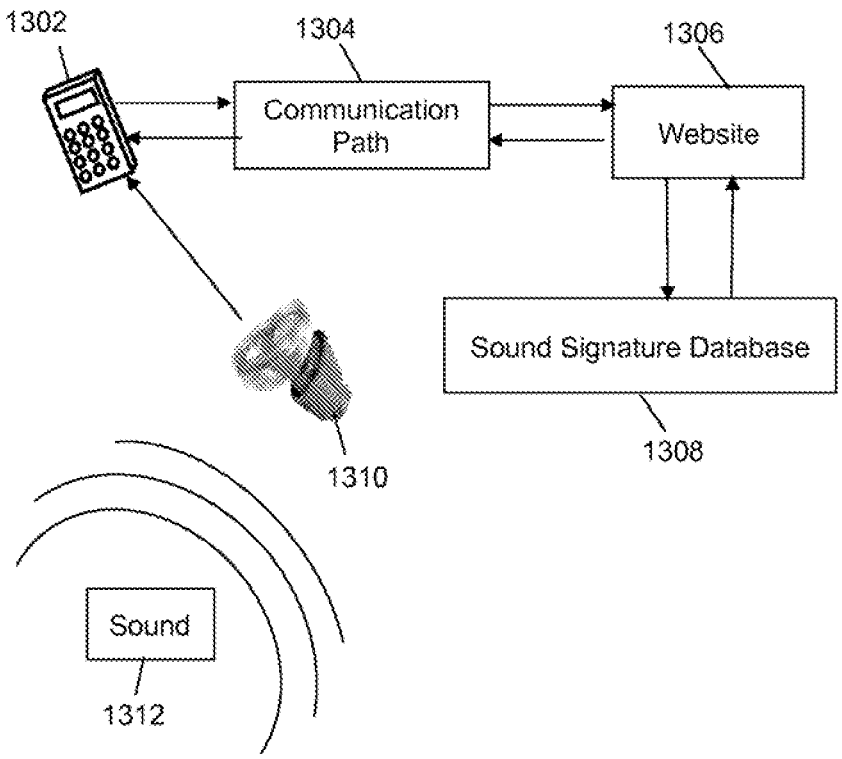
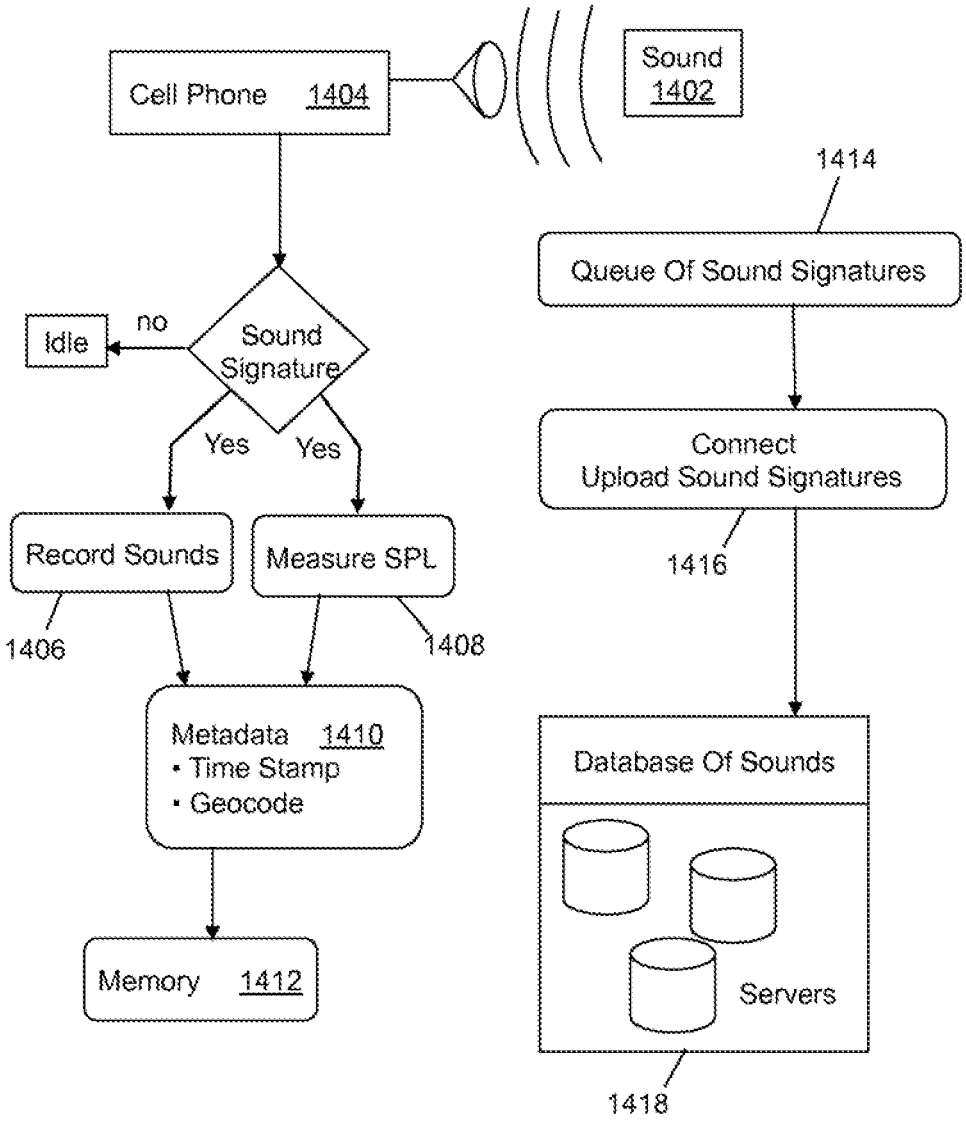

1302
1304
Communication Path
1306
Website
Sound Signature Database
1308
1310
Sound
1312

FIG. 14


Cell Phone 1404
Sound 1402
1414
Queue Of Sound Signatures
Idle
no
Sound Signature
Yes
Yes
Connect Upload Sound Signatures
1416
Record Sounds
Measure SPL
1406
1408
Metadata 1410
• Time Stamp
• Geocode
Database Of Sounds
Servers
Memory 1412
1418

PERSONALIZED SOUND MANAGEMENT AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority benefit to U.S. application Ser. No. 17/203,731, filed 16 Mar. 2021, which is a continuation of U.S. application Ser. No. 16/671,689, filed 1 Nov. 2019, which is a continuation of U.S. application Ser. No. 14/846,994, filed 7 Sep. 2015. U.S. application Ser. No. 14/846,994 is a continuation of U.S. application Ser. No. 12/560,097 filed on 15 Sep. 2009 and claims the benefit of U.S. provisional patent application No. 61/098,914 filed 22 Sep. 2008. The disclosure of the aforementioned applications are all incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The invention relates in general to methods of managing sound, and particularly though not exclusively, is related to personalized sound management.

BACKGROUND OF THE INVENTION

The world of two hundred years ago is substantially different than the present day earth. Similarly, the acoustic environment that surrounds us is also changing. For example, the sounds of a large city have changed as the mode of transportation transitioned from walking and horse and buggy, to cars, subways, and airplanes.

In general, humans are continuously inundated by a diversity of sounds. Many of the sounds are not critical to our lives but our brain processes these sounds and tries to distinguish between them. Background sound levels can also make it difficult to hear sounds that are important. Too much acoustic information can cause an auditory overload that can impact both the health and safety of an individual.

SUMMARY

The invention relates in general to methods and system for implementing a suite of personalized sound applications for modifying a user's acoustic environment and more particularly, though not exclusively, to facilitating the adoption of the technology, ensuring the technology functions properly, protecting both the manufacturers and consumer, and providing user selection and control over the management of sound.

At least one exemplary embodiment is directed to a method of personalized sound management comprising the steps of: selecting at least one of a plurality of personalized sound management applications through a client system where the user selects the at least one of the plurality of personalized sound management applications from a website; accepting a subscription contract for using the at least one of the personalized sound management applications; and loading the selected at least one of the plurality of applications from a server system to a device where the device has at least one microphone, at least one speaker, and a processor configured to identify sonic signatures where each sonic signature is identified using a Gaussian mixture model.

At least one exemplary embodiment is directed to a method of implementing personalized sound management comprising the steps of: recording sound with a microphone of a communication device; analyzing the sound for acoustic information relevant for personalized sound management applications; storing a sonic signature in a memory of the communication device; calculating a sound pressure level of the sonic signature; and attaching and storing metadata related to the sonic signature and sound pressure level including a time stamp and geocode.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary embodiments of the present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

FIG. **1** illustrates a block diagram of the interaction of personalized sound management in accordance with at least one exemplary embodiment;

FIG. **2** illustrates a block diagram of a partial list of applications for personalized sound management in accordance with at least one exemplary embodiment;

FIG. **3** illustrates a block diagram of the interaction of a personalized management enabled device with other devices in accordance with at least one exemplary embodiment;

FIG. **4** illustrates a flow chart of a process of providing personalized sound management in accordance with at least one exemplary embodiment;

FIG. **5** illustrates a flow chart of an application testing in accordance with at least one exemplary embodiment;

FIG. **6** illustrates a flow chart of the testing of a personal sound management device in accordance with at least one exemplary embodiment;

FIGS. **7***a* and **7***b* are diagrams illustrating a consumer purchase process in accordance with at least one exemplary embodiment;

FIG. **8** illustrates a flow chart of registering a new device that includes personalized sound management applications in accordance with at least one exemplary embodiment;

FIG. **9** illustrates a flow chart of enabling the new device in accordance with at least one exemplary embodiment;

FIG. **10** illustrates a flow chart of updating a unit or device in accordance with at least one exemplary embodiment;

FIG. **11** illustrates a diagram of a device for implementing personalized sound management in accordance with at least one exemplary embodiment;

FIG. **12** illustrates a block diagram of a device for implementing personalized sound management in accordance with at least one exemplary embodiment;

FIG. **13** illustrates a diagram of a communication device or earpiece configured to provide sonic signatures to a sonic signature database in accordance with at least one exemplary embodiment; and

FIG. **14** illustrates a block diagram of a cell phone capturing a sonic signature and providing the sonic signature to a database of sounds in accordance with at least one exemplary embodiment.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS OF THE PRESENT INVENTION

The following description of exemplary embodiment(s) is merely illustrative in nature and is in no way intended to limit the invention, its application, or uses.

Processes, techniques, apparatus, and materials as known by one of ordinary skill in the art may not be discussed in detail but are intended to be part of the enabling description where appropriate. For example specific computer code may not be listed for achieving each of the steps discussed, however one of ordinary skill would be able, without undo

experimentation, to write such code given the enabling disclosure herein. Such code is intended to fall within the scope of at least one exemplary embodiment.

Additionally, the sizes of structures used in exemplary embodiments are not limited by any discussion herein (e.g., the sizes of structures can be macro (centimeter, meter, millimeter, micro (micro meter), nanometer size and smaller).

Notice that similar reference numerals and letters refer to similar items in the following figures, and thus once an item is defined in one figure, it may not be discussed or further defined in the following figures.

In all of the examples illustrated and discussed herein, any specific values, should be interpreted to be illustrative only and non-limiting. Thus, other examples of the exemplary embodiments could have different values.

FIG. **1** is a diagram of personal sound management in accordance with at least one exemplary embodiment. In our global community **100**, each person is unique. The differences between individuals can be genetic, cultural, environmental, personal, or physical to name just a few. The combination of these traits is what makes us unique. One of the main senses a human relies on is our auditory sense. Hearing impacts every aspect of our life from communication to safety. How each individual perceives and uses sound is also unique.

From an acoustic perspective, sound pressure levels have been rising steadily. The diversity of sounds is also increasing. The human brain continuously processes the acoustic information provided by the ears. Both the sound pressure levels and the sound diversity puts increasing strain on a person to determine what they need to hear versus what they are hearing. Ultimately, this "acoustic overload" can manifest itself in physical ailments and health risks such as stress, sleeplessness, and depression.

A person **102** has an acoustic space **104** from which a majority of sounds they receive emanate. Some of the sounds are useful to person **102** and some sounds may have no use. Acoustic space **104** can be large or small. Acoustic space **104** will change with time and location. For example, acoustic space **104** can be a room, a stadium, a forest, an automobile, a plane, or the ear canal of person **102**. Personalized sound management (PSM™) **106** is the ability to modify what is received from acoustic space **104** thereby tailoring or personalizing the received acoustic information to meet the needs of person **102**.

Devices **108** are a source of acoustic information within acoustic space **104**. In general, device(s) **108** have a speaker, a microphone, or one or more of both. In general, application hardware and software **110** is incorporated in, although can be external also, device(s) **108** to allow personalization of acoustic space **104**. Person **102** selects the applications and controls device(s) **108** to modify acoustic space **104** to meet their personal needs and wants. The benefit and utility of personalizing and managing sound received by person **102** will be disclosed in more detail.

FIG. **2** is a diagram illustrating a partial list of applications for personalized sound management in accordance with at least one exemplary embodiment. A user **202** has an acoustic space **204** that includes both real sounds and potential sounds. In many cases, acoustic space **204** can be inundated with a variety of sounds not under control of user **202**. This lack of control over acoustic information and sound within acoustic space **204** can make for a reduction in quality of life, loss of efficiency, or more seriously affecting user's **202** health and safety.

In at least one exemplary embodiment, a user **202** selects **201** at least one personalized sound management application from a personalized sound management applications list **206**. Although only a partial list, applications such as Safe Space™ **216**, EarGuard™ **218**, Quiet Call™ **220**, Ear Sticky™ **230**, Hearable™ **222**, Always On-Recording™ **224**, Earbliss™ **226**, Hear & Tell™ **232**, and Ear Mai™ **228** will be used to illustrate how acoustic space **204** is personalized and managed for the benefit of user **202**. A more detailed explanation of personalized sound management applications **206** will be described.

The selected applications of user **202** are loaded into ROM **212**. An operating system **208** is configured operably with device **210** and ROM **212**. Operating system **208**, in conjunction with personalized sound management applications **206**, provides an interface to the user for personalized sound management **214** to meet user needs to manage user acoustic space **202** and for controlling device **210**.

ROM **212** can be read only memory such that the selected applications from personalized sound management list **206** cannot be tampered with or rewritten. However in at least one exemplary embodiment ROM **212** can also be memory that can be read and written to so that a user can change settings. Alternately, ROM **212** can be other types of memory such as fe-ram, phase change memory, magneto-resistive memory, hard drive, sram, dram, eprom, eeprom, and other non-volatile or read only memories where the selected applications are secure from any type of downloading, tampering, or modification through physical or software protection. Monitoring of ROM **212** and the selected applications can also be added where notification is sent or device **210** is disabled when an improper action is detected. ROM **212** ensures that an application will operate as disclosed for user **202**.

Components of device **210** can be built in a single unit or operatively coupled units. For example, multiple devices of **210** can be wired, optically connected, wirelessly connected or a combination thereof. Operating system **208** can be run remotely to operate device **210** or reside within device **210**. Similarly, ROM **212** can be located in device **210** or remote to device **210**. In at least one exemplary embodiment, operating system **208** resides in ROM **212**. Device **210** typically has at least one microphone or at least one speaker, or both. The at least one microphone provides acoustic information for use in conjunction with personalized sound management applications. The at least one speaker provides acoustic information to user **202** and acoustic space **204**. Device **210** has a microprocessor (not shown) for running applications **206**. In at least one exemplary embodiment the microprocessor is dedicated to running personalized sound management applications **206**.

In general, personalized sound management applications are customizable point solutions that allow user **202** to handle a variety of tasks associated with managing acoustic space **204**. The selection of personalized sound management applications will depend on the person, the device, and the acoustic space being managed. Non-limiting examples of devices that can use personalized sound management applications with the appropriate hardware and operating system, are earpieces, media devices, and vehicles.

Described hereinbelow are brief overviews of the user selected personalized sound management applications:

Safe Space™ **216** is an "intelligent hearing" application that detects and outputs a response based on the identification of a recognized sound. The concept of recognizing sounds is described as Sonic Signature Detection. Safe

Space™ **216** also includes a user defined hierarchy and can provide responses based on the hierarchy.

A brief example is provided of how Safe Space™ **216** manages the acoustic space corresponding to the interior of an automobile. As is well known, automobiles are designed to have a quiet interior space. Sound insulation is deliberately placed around the car interior to attenuate sounds coming from the car exterior. Furthermore, automobile drivers often listen to high volume music while driving. This combination makes it difficult to hear sounds such as emergency vehicles. People often get seriously injured because they hear the emergency vehicle when it is in close proximity to the vehicle and panic causing an accident. All descriptions below describing personalized sound management applications assume that the device using the application has incorporated within it the hardware and software required to run the application and perform the application function.

In this example, Safe Space™ **216** detects emergency vehicle horns when they are a substantial distance away. In at least one exemplary embodiment, a microphone is exterior to the car and can pick up sounds in the ambient or car exterior. Sonic signatures related to emergency vehicles such as fire trucks, ambulances, and police cars are stored in the system. Safe Space™ **216** analyses sounds from the microphone. A response is provided if one of the stored sonic signatures is detected. In at least one exemplary embodiment, upon detecting a fire truck siren, Safe Space™ **216** can initiate playing the identified signal through the car stereo system for the car driver to hear and respond to. In at least one exemplary embodiment, Safe Space™ **216** can calculate the direction, distance, and street (through GPS) of the approaching emergency vehicle. The information is then provided visually or vocally to the driver. For example, the car stereo automatically turns down the music and states through the speaker system that an ambulance is coming east bound on 3.sup.rd Street or an ambulance is approaching from the right.

EarGuard™ **218** is a personalized sound management application that improves listening quality and safety. Hearing disorders are increasing at a very high rate. Many people live in an environment such as a noisy urban environment or an industrial manufacturing area where sound pressure levels are consistently high. Moreover, people themselves are subjecting themselves to loud and sustained sounds. Examples of extreme or sustained sound exposure are portable media players using earbuds, sport shooting, and rock concerts. The trend is a growing population of people that have or will have hearing problems.

The ear is a very sensitive instrument having a large dynamic range that allows us to hear sounds ranging from a whisper to a shout. Subjecting the ear to man-made cacophony is now known to metabolically exhaust the highly specialized sensory cells in the inner ear, causing them to die and be replaced by scar tissue in the hearing organ. Ear Guard™ **218** is an application that monitors the sound exposure of the user and protects the ear from damage.

Briefly, Earguard™ **218** improves listening quality and safety by employing a personal hearing zone that measures sound levels within the ear and in one exemplary embodiment an intelligent level control to protect against over amplification. Earguard™ **218** includes a sound pressure level (SPL) dose management system. The SPL dose management system takes into account both transient and long term sound. In at least one exemplary embodiment, when sound at the user's eardrum is above a certain threshold known to begin the process of metabolically exhausting the ear, the metric known as SPL Dose increases. The SPL dose decreases when sound is below that threshold according to a recovery function that mirrors the recovery of the ear from excessive sound exposure. In at least one exemplary embodiment, Earguard™ **218** will indicate to the user damage to the ear is likely if the sound exposure is continued. In this scenario, the user has the control to take the appropriate action to protect his/her ears.

In at least one exemplary embodiment, an intelligent level adjustment system is a personalized sound management application that automatically estimates the preferred listening level of an audio content signal (e.g. speech or music audio from a device) depending on an analysis of the level, other acoustic features of the ambient environment, and an analysis of the audio content signal. Thus, a human-machine relationship is nurtured with this bi-directional control flow from human to the intelligent level adjustment system and from intelligent level adjustment system to the human user.

A substantial benefit of an application such as Earguard™ **218** is the protection of the ear from damage. Furthermore, this safeguard if propagated will prevent hearing loss thereby reducing the financial burden on the economy in years to come for the individual, business, and government for hearing loss remedies. Thus, using Earguard™ **218** could not only stem the growth in hearing related problems but greatly reduce it over the years to come.

Quiet Call™ **220** is an application that allows user **202** having heard a voice message to respond to the remote caller through a non-verbal means. An example of a non-verbal response is a key-pad entered text message. The entered text message is converted to a speech audio message and is sent to the remote caller. The caller then receives the speech audio message.

An example of the utility of Quiet Call™ **220** is illustrated when user **202** is in an important business meeting but is required to provide input to another remote meeting. User **202** receives the voice message sent from someone in the remote meeting. User **202** responds by entering the response through his/her phone keypad; the text is converted to voice and sent to the person at the remote meeting who sent the original message. User **202** does not have to interrupt the meeting to listen to the voice message nor to reply. Thus, the meeting attended by user **202** can move forward with little or no loss of momentum that would occur if the meeting was disrupted by the call.

Hearable™ **222** is a speech enhancement application that improves voice communication. For example, Hearable™ **222** can be used with an earpiece device having at least two microphones, an ambient sound microphone for receiving sounds in the ambient environment and an ear canal microphone for receiving sounds in the ear canal. A common use for the earpiece would be with a communication device such as a cell phone or other phone system. The earpiece using the Hearable™ **222** application would normally use the ambient sound microphone for receiving and transmitting the user's spoken voice. In this mode, the user's voice will be natural sounding and easily recognizable on the receiving end.

In a noisy environment it can be difficult to carry on a telephone conversation. The ambient sound microphone will pick up the voice and the noise in the ambient environment. The earpiece will switch to the ear canal microphone when the ambient sound microphone detects a high background noise level. The user's voice is readily picked up by the ear canal microphone but the noise in the ambient environment is substantially reduced. Switching to the ear canal microphone allows the receiving party to clearly hear the user's

voice. The problem with using the ear canal microphone is that user's voice received in the ear canal sounds different because of frequency roll off in the upper spectrum of the voice range. Although the user can be heard clearly, the user's voice may not sound right to the receiving end.

Hearable™ **222** is a personalized sound management application that improves the sound quality of the user's voice. Hearable™ **222** uses a combination of the sound received by the ambient sound microphone and the ear canal microphone to create a more natural sounding voice. The combination of the two signals is a function of the background noise level. Explaining further the signal from the ambient sound microphone is used less as the background noise level increases. Hearable™ **222** allows a user to have a conversation in a noisy environment while providing a high quality voice signal that is intelligible and recognizable at the receiving end.

Always On-Recording™ **224** is a personalized sound application that acts as its name implies. A device using the Always On-Recording™ **224** application is recording the most current audio information for user recall. The recording is stored in a buffer that will allow the user to immediately access the audio information. The buffer will have a finite amount of storage. The recording time will be a function of the buffer or memory available for the Always On-Recording™ **224** application.

Always On-Recording™ **224** provides utility for short durations of recording. For example, in an application where a user is receiving information such as a phone number or driving directions. The user knows that the device employing Always On-Recording™ **224** has the stored acoustic information and can immediately listen-again to the buffer contents thereby repeating the phone number or driving directions. Similarly, if the user was discussing a contract term and wanted to know exactly what the person said, the user could immediately re-listen to make sure that what they thought they heard is exactly what they heard.

Earbliss™ **226** is a personalized sound management application to provide acoustic isolation from someone who snores while allowing other sounds to be heard. A large percentage of the population suffers though sleepless nights because of the sounds generated by people with sleep apnea and more generally due to loud snoring. Moreover, sleep deprivation can have serious consequences related to health and disposition.

Earbliss™ **226** is a sleep zone technology that utilizes sonic signature detection to insulate sleep partners against intrusion from snoring while still providing awareness of priority sounds. In this example, a sonic signature is acoustic information related to the sounds of a person snoring. In at least one exemplary embodiment, Earbliss™ **226** is an application that is used in conjunction earpieces.

Sealing the ear canal with ear plugs will attenuate the snoring but also blocks out all sounds. Hearing is one of the most vital senses that we have. Under normal conditions we cannot turn off our hearing which allows us to wake in a critical situation. Ear plugs will block out sounds of consequence. For example, the user may not hear their baby crying or a child leaving their room.

Earbliss™ **226** enables a user to attenuate snoring while hearing other sounds around them. The earpieces fit in the ear canal of the user to seal or partially seal the ear canal. The earpieces have an ambient sound microphone for receiving acoustic information from the ambient environment and an ear canal receiver for providing sound to the user's ear canal. As mentioned previously, the earpieces will have a sonic signature related to snorer's snoring stored in memory in the device.

The ambient sound microphone picks up all sounds in the ambient environment including the snorer's snoring. The earpiece processes all the acoustic information coming from the ambient sound microphone and looks for signals similar to stored sonic signatures. Pattern recognition approaches are applied based on the known sonic signatures to detect the snoring sounds from their corresponding sonic signatures. More specifically, sonic signatures can then be compared to learned models to identify a corresponding snoring sound. Once identified the snoring sound is suppressed and not output to the ear canal by the ear canal receiver. Thus, the wearer of the earpieces does not hear the snoring.

Conversely, sounds in the ambient environment that are not recognized through the processing of acoustic information by the earpieces can be passed transparently to the ear canal receiver for reproduction within the ear canal. In this mode, the sound produced in the ear canal sufficiently matches the ambient sound outside the ear canal, thereby providing a "transparency" effect other than the suppressed sonic signature (snoring). The earpieces can also enhance sound. For example, the earpieces having sonic signatures related to a fire truck siren or a baby crying can detect either signal and then amplify the signal (fire truck siren, baby crying) so as to make the wearer of the earpieces aware of the signal's detection. Thus, Earbliss™ **226** modifies the acoustic environment of the user to eliminate what does not need to be heard while allowing the user to be aware of other sounds in a normal context.

Ear Mail™ **228** is a personalized sound management application for converting text to voice. In particular, Ear Mail™ **228** provides great utility to users of email and text messaging although not limited to these examples. Email and text messaging is becoming a very popular form of communication among a large portion of the population. It is not always convenient or in some cases not prudent to review written text depending on the situation.

Ear Mail™ **228** converts the text of a message or email to a speech audio message using a text to speech algorithm. The converted speech audio message is replayed through a loudspeaker coupled to a device using the Ear Mail™ **228** application. For example, Ear Mail™ **228** used in a smart phone coupled to the stereo system of a car through a blue tooth connection could playback the text or emails through the car speakers. The user could hear their messages while driving safely down the road.

Ear Sticky™ **230** is a personalized sound management application for recording information that can be saved and used for future use. In at least one exemplary embodiment, Ear Sticky™ **230** is a mobile communication application that can be used in a device such as a cell phone or an earpiece that is operably coupled to other devices. Ear Sticky™ **230** can record communication through a device or sounds in the ambient environment. Sounds in the ambient environment are recorded by an ambient sound microphone.

In a first example of an Ear Sticky™ **230** application, a conversation between a husband and wife occurs and a list of items to pick up at several stores is disclosed. The user of Ear Sticky™ **230** does not need to write down or remember this list. The conversation is being recorded and stored in a buffer. The user activates Ear Sticky™ **230** to store the recorded conversation to be reviewed at a later time. Thus, the user of Ear Sticky™ **230** could recall and listen to the list on the way home to ensure that the right items are picked up at the appropriate store.

In a second example of an Ear Sticky™ **230** application, a device records with an ambient sound microphone. For example, the user of Ear Sticky™ **230** comes up with a great concept to solve a problem he or she has been working on for some time. The user can enable Ear Sticky™ **230** and uses the ambient sound microphone to record his or her voice to convey the idea, concept, or thoughts and store it for review at a later time. In general, Ear Sticky™ **230** provides utility and convenience in storing and recalling sounds in one's acoustic space.

Hear & Tell™ **232** is a personalized sound management application for recording a sound, training a Gaussian mixture model to learn features of the sound and then storing the Gaussian mixture model in memory of the device. A user of Hear & Tell™ **232** can record the sound or provide a sound, called herein as a sonic signature. The device is operably coupled to at least one microphone to compare sounds received from the microphone against the stored sonic signature. The device can perform an operation that modifies the user's acoustic space **204** once a sound is identified as being similar to a sonic signature. Examples of several operations the device can perform are passing the detected signal through to the user, boosting the sound such that the user is made aware of the detected sound, rejecting the sound so the user does not hear the detected sound, attenuating the detected sound, and replacing the detected sound with an alternate sound to name.

The Hear & Tell™ **232** application will store a Gaussian mixture model (GMM) for every sonic signature that it has been trained to recognize. Each GMM is completely specified by a mixture of mean vectors, a mixture of covariance matrices, and a mixture of weights.

An example of a warning sound (e.g. siren of emergency vehicle) will be used to further illustrate the Hear & Tell™ **232** learning application. Each GMM provides a model for the distribution of the feature statistics for each warning sound in a multi-dimensional space. Upon presentation of a new feature vector, the likelihood of the presence of each warning sound can be calculated. In at least one exemplary embodiment, each warning sound's GMM is evaluated relative to its anti-model, and a score related to the likelihood of that warning sound is computed in order to determine if a sound is detected. A threshold can be applied directly to this score to decide whether the warning sound is present or absent. Similarly, a sequence of scores can be relayed and used in a more complex rule set to determine absence or presence of the sound. Thus, Hear & Tell™ **232** allows a user to store, model, and train a device for sonic signatures under user control and selection thereby allowing a user to modify their acoustic space through the detection of a sound and response by the device.

In general, personalized sound management applications are customizable point solutions that allow user **202** to handle a variety of tasks associated with managing acoustic space **204**. The selection of personalized sound management applications will depend on the person, the device, and the acoustic space being managed. Examples of devices that can use personalized sound management applications with the appropriate hardware and operating system, but not limited to these examples, are earpieces, media devices, and vehicles.

As described hereinabove, a suite of personalized sound management applications **206** are provided. The user **202** can select the desired applications and have control over their acoustic space **204**. The selected applications are stored in ROM **212**. Under user control, user **202** selects the parameters of personalized sound management applications **206** using operating system **208** for implementing applications **206** in device **210** for managing acoustic space **204** based on the individual's needs and wants.

FIG. **3** is a diagram illustrating a module **300** for implementing personalized sound management in accordance with at least one exemplary embodiment. Module **300** comprises an H-Chip™ **302**, a ROM **304**, an operating system **306**, and user selected personalized sound management applications **308**. In at least one exemplary embodiment, module **300** comprises the H-Chip™ **302** with ROM **304** built into H-Chip™ **302**. Both operating system **306** and user selected personalized sound management applications **308** are stored on ROM **304**. Alternately, H-Chip™ **302** and ROM **304** can be separate chips allowing for a larger block of memory.

H-Chip™ **302** is a microprocessor, DSP, or logic circuit that implements personalized sound management applications **308**. H-Chip™ **302** is optimized for low power dissipation while running user selected personalized sound management applications **308**. In at least one exemplary embodiment, H-Chip™ **302** can be a dedicated engine for running applications **308**.

Module **300** comprises an application engine (firmware) and a dedicated processor that simplifies the integration of user selected and user controlled personalized sound management applications **308** into a device. In an exemplary embodiment, module **300** is integrated into each device in devices **314**. Devices **314** typically, although not always have at least one microphone and at least one speaker. User **310** in conjunction with module **300** can personalize how each device manages sound to the user.

An additional aspect of module **300** is that a third party manufacturer merely builds the acoustic portion of their device around module **300**. In an exemplary embodiment, a manufacturer does not and cannot modify operating system **306** and user selected personalized sound management applications **308**. Thus, the manufacturer saves time, effort, and money through the seamless integration module **300** into a single hardware solution for maximum transportability into 3.sup.rd party form factors.

FIG. **4** is a diagram illustrating a process of providing personalized sound management in accordance with at least one exemplary embodiment. In general, the technology related to providing personalized sound management comprises hardware components and software. In at least one exemplary embodiment, the hardware **402** comprises transducers **404** and H-Chip™ **406**.

Transducers **404** are speaker and microphones for respectively providing and receiving sound in an acoustic space. Depending on the application, the size and form factor of transducers **404** may be a critical design parameter. Transducers **404** can be a speaker for providing high fidelity sound to enhance a user's experience. Similarly, transducers **404** can be a microphone for receiving acoustic information and in some cases can pick up sounds inaudible to the user.

H-Chip™ **406** can be a microprocessor, digital signal processor, logic circuit, or applications specific integrated circuit for use implementing the software applications listed hereinabove and other programs related to personalized sound management. H-Chip™ **406** includes operating system **408** specific for managing the device as it relates to personalized sound management and allows user control to adjust the parameters of each application for their specific needs.

Hardware **402** can be integrated into existing devices or next generation devices for adding utility, providing safety, and allowing personalization of a user's acoustic space.

Providing hardware **402** enables device manufacturers **410** to rapidly integrate the technology into their products. This will quicken the adoption cycle of the technology for the benefit of the general public in health and safety, and for the individual through personalization. Hardware **402** can be a circuit board to which transducers **404** and H-Chip™ **406** are operatively attached.

Device manufacturers **410** can provide their own hardware **414** or use transducers **404** and H-Chip™ **406**. The operating system and application software is incorporated **412** and stored in read only memory (ROM). In at least one exemplary embodiment, operating system **408** and the application software can be stored in ROM. Using read only memory for storage prevents device manufacturers **410** or consumers from tampering with the software code thereby maintaining the integrity of the system and how it performs for the user. Note herein when referring to ROM storage, at least one exemplary embodiment can include RAM or other read/write storage methods.

People in the consumer product industry have stated that any new product and even old products in the hands of consumers may produce liability issues that companies associated with the product have to deal with. This often delays an introduction of a product or adds substantial cost to a product launch. In at least one exemplary embodiment, device manufacturers **410** provide their product for certification **416**. In at least one exemplary embodiment, certification **416** is performed by an independent company from device manufacturers **410**. Certification **416** is a process whereby a new product is exhaustively tested to ensure the device will perform to specification under a variety of conditions and tolerances. In particular, certification **416** tests the operating system and the device performance in implementing the applications related to personal sound management. Should the device not pass certification testing, it can be repaired or redesigned. The repaired or redesigned device can then undergo certification **416** to determine if it meets the test specifications.

In at least one exemplary embodiment, an insurance policy **418** may be provided covering the device manufacturers **410** using operating system **408**, hardware **402**, and the application software. This provides substantial benefits in that the device manufacturers **410** can deploy the technology with less risk. Moreover, each company providing devices will know that the personalized sound management system is similar or identical to others in the market. As mentioned hereinabove, the operating system and application software can be stored in ROM ensuring it cannot be rewritten. Additional measures can be taken to determine if the software is being used out of context and shutting down the operation of the device.

Once tested and certified, device manufacturers **410** can manufacture, market, and sell devices with personalized sound management **424** and be covered from a liability perspective under provisions in the insurance policy **418**. A consumer purchases **420** a certified device and may also be covered under the same insurance policy **418** or may have a second policy directed to the consumer. Consumer protected **422** under insurance policy **418** and having certification **416** will instill consumer confidence to the quality and reliability of the device. This will be discussed in greater detail hereinbelow. Thus, this process is very efficient in creating manufacturer adoption of the personalized sound management technology while protecting both device manufacturers **410** and the consumer.

FIG. **5** is a diagram illustrating application testing in accordance with at least one exemplary embodiment. Device manufacturers **502** develop, prototype, and manufacture products **506**. Products **506** include hardware and operating system **504** for running and performing Personalized Sound Management (PSM™) applications **508**.

In at least one exemplary embodiment, hardware and operating system **504** is capable of running all personalized sound management applications **508**. Products **506** may or may not use all of personalized sound management applications **508**. Similarly, an end user or customer of products **506** may or may not use all of personalized sound management applications **508**.

Hardware and operating system **504** of products **506** are loaded with all personalized sound management applications **508**. The hardware and operating system **504** are exercised in testing **510** to ensure that it can run personalized sound management applications **508** per specification. Product **506** may or may not be tested for all personalized sound management applications **508** depending on the capability of the device. Products **506** will be tested **510** for the implementation of all personalized sound management applications it is capable of running to meet user specifications for the product (i.e. product certification **512**). In at least one exemplary embodiment, should a product run only a subset of personalized sound management applications, the product can be designed and tested to lock out the running of applications not specified for the particular product (even though hardware and operating system **504** can run personalized sound management applications **508**).

A scale of economy for developing and manufacturing hardware and operating system **504** is achieved by having a number of different device manufacturers **502** standardize on the engine (hardware and operating system **504**) for implementing personalized sound management. Consistency of product, ability to expand scope of product, and lowering cost through volume manufacturing are all achieved by this methodology. In the example where liability insurance may be purchased by the product certification company (or other company) testing **510** all personalized sound management applications **508** in products **506** ensures that hardware and operating system **504** perform per specification independent of the product it is placed in. Furthermore, having little or no variation on the operation of hardware and operating system **504** and personalized sound management applications **508** minimizes risk. An added benefit is that a large statistical database of diversified products is generated that will allow improvements to managing personalized sound management devices to improved device performance as well as lower liability risk. The consumer benefits by having a highly exercised and stable product that improves their health, safety, and quality of life.

FIG. **6** is a diagram illustrating testing of a personalized sound management product **602** in accordance with at least one exemplary embodiment. In at least one exemplary embodiment, testing of all products incorporating personalized sound management applications are tested by a single entity. Personalized sound management product **602** can be developed and manufactured by a number of different companies. As previously mentioned, this allows the single entity, should it so desire to purchase a liability insurance policy that covers the manufacturers making personalized sound management product **602** and consumers using personalized sound management product **602**.

Personalized sound management product **602** is tested by certification laboratory **604**. In at least one exemplary embodiment, certification laboratory **604** is independent from the different manufacturers that develop personalized sound management product **602** thereby providing unbiased

testing. Testing **614** of hardware **606**, software **608**, and manufacturing **610** are performed on personalized sound management product **602**. Testing **614** is related to operation and performance of personalized sound management applications. Hardware testing includes the processor, transducers, and other elements, which implement the personalized sound management of the device. Testing of software **608** includes the operating system and personalized sound management applications. Testing **614** includes reliability **616** and quality **618** testing. Testing **614** can also include human testing because in some embodiments, personalized sound management product may be worn in an orifice of the human body.

Upon passing testing **614** the personalized sound management product **602** is certified by certification laboratory **604**. A product certified **620** can include some form of warranty, indemnification, and liability insurance for the device. Problems or issues with personalized sound management product **602** are reported to the company should it fail for any reasons. Corrective action can be taken and the device retested to determine if the issue has been resolved.

In at least one exemplary embodiment, certification laboratory **604** or its parent company will brand the product by placing a trademark or company logo on the approved personalized sound management product **602**. The trademark or logo represents the incorporation of its personalized sound management technology in the product (hardware, software, and intellectual property) as well as the certification indicating the quality and reliability of the device.

FIG. **7***a* is a diagram illustrating a consumer purchase process for a personalized sound management product in accordance with at least one exemplary embodiment. A consumer reviews a number of different devices such as earpieces in a display area. The display area allows the consumer to look, feel, and touch the hardware. The consumer focuses on an earpiece **701** in the display area and wants to learn more about the device.

A sales person can demonstrate earpiece **701** allowing the consumer to test the functions and performance of the device. A demonstration room or test environment can be used to illustrate performance differentiation when compared to other earpieces. In at least one exemplary embodiment, earpiece **701** is an in-ear device that has a removable and disposable sealing section. This allows consumer testing using earpiece **701** while maintaining a sanitary condition by disposing of the sealing section after each test session.

The consumer indicates to the sales person that he or she would like to purchase earpiece **701**. The sales person accesses a computer that is coupled to server system for completing a purchase transaction. The consumer provides registration information that is entered into a database in a step **703**. The consumer or the sales person can enter the information into the database. The registration information **705** comprises information such as personal, financial, business, and preference. Personal information relates to data such as age, sex, home address, telephone number, email address, which identifies the consumer. Financial information relates the consumer's ability to pay such as credit history, credit card for billing, job information, and banking institutions. Business information relates to a business purchase of the component. Similar to above, business identification and business financial information would be entered with the purchase. Preferences relate to things such as how the consumer wants to be contacted (email, phone), do they want to be made aware of upgrades for their device, and other products they might have interest in. Other information or user experiences could also be collected during the registration process.

The unit selected by the consumer is then entered into the system in a step **707**. In at least one exemplary embodiment, the system identifies the unit and provides a listing of the hardware, software, and subsystems that work with the earpiece **701**. The consumer can look at the options available in a step **709** and select among these options. In at least one exemplary embodiment, the selection process can be facilitated by topic, occupation, or other characteristics by providing a list of typical user features applied to earpiece **701**. For example, the consumer is purchasing earpiece **701** for a multimedia player. Earpiece **701** provides a substantial improvement in noise attenuation, musical clarity, definition, and dynamic range. The consumer is interested in the safety aspect (and selects this topic on the kiosk) provided by earpiece **701** in alerting the user to an emergency event. For example, earpiece **701** can detect and make the user aware of sirens, emergency sounds, alarms, etc. that would be difficult to hear when listening to music. The consumer by looking at the "safety" topic can select appropriate applications software and sonic signatures to alert the user of a safety situation for their specific device. The consumer can continue to look through other topics and select hardware and software that supplements and implements the desired user experience.

As mentioned previously, the options can be provided in a step **709** in many different formats. Another format of providing options is by occupation. For example, a dentist may be provided a package to outfit the entire office and patients. The earpieces substantially reduce noise related to drilling which are both a psychological barrier for dentistry and a hearing loss mechanism for people working in a dentist office. The occupation package can provide wireless communication between devices allowing dentists, assistants, and patients to talk or listen to music even in a noisy environment. Replaceable in-ear sealing sections would allow the staff to maintain sanitary conditions with each new patient. After reviewing the consumer selects the appropriate hardware and software to personalize their sound space (on the kiosk or computer) in a step **711**.

In at least one exemplary embodiment, the selected application software provided to earpiece **701** is a subscription whereby the consumer pays a monthly fee to use the applications. Alternately, the selected application software can be a license or purchase associated with the earpiece **701** whereby a one time fee is paid. The consumer can discuss the terms of the agreement with the sales person or review the contract on the computer. If the consumer approves, the contract is signed or accepted and an initial payment is made for the hardware and software in a step **713**. The consumer can have the subscription payment automatically billed to a credit card or other automatic payment methodology to ensure uninterrupted service.

The purchased earpiece is then connected via a wired or wireless connection to download the selected software and enabled in a step **715**. A wired connection **717** such as a mini USB cable is shown in the illustration. Wired connection **717** connects to a server system having the appropriate software. In at least one exemplary embodiment, the selections from step **711** can be stored in memory and used to direct the downloading of software to the device, verify the software can be used in the device, and that the appropriate software has been loaded.

FIG. **7***b* is a diagram illustrating a consumer purchase process for a personalized sound management product in

accordance with at least one exemplary embodiment. A consumer **702** can purchase personalized sound management product hardware **704** and personalized sound management application software **706**. Software **706** works with hardware **704** to personalize and manage sound for consumer **702** for providing utility, safety, and health benefits.

Hardware **704** can range from a complete product such as a communication device, sound device, or earpiece to ancillary components for enhancing the look of the device or adding further hardware features. In the event that consumer **702** purchases hardware **704**, customer information **708** is required to continue with purchase. In general, customer name, address, personal information and financial information are typically required to purchase hardware **704**. Other information can also be collected through a questionnaire or some form of incentive. Should customer information **708** exist and consumer **702** is in good stead then generating customer information **708** is not required and the order process continues. Any issue that occurs in checking customer information **708** will be brought up for rectification to consumer **702**. The hardware **710** that consumer **702** selected is verified and place order **712** is performed.

Personalized sound management application software **706** is a suite of applications that consumer **702** selects for their specific needs. Once customer information **708** has been established, consumer **708** is provided subscription information **714**. Use of personalized sound management application software **706** is based on a periodic fee or subscription (for example, a monthly fee). Subscription information **714** informs consumer **702** as to the periodic subscription fees associated with the software **706**, terms of use, bundled packages of applications, and other pertinent information to complete the decision process. Should consumer **702** approve of the terms, a contract **716** is provided to the customer to accept or decline. A bill **718** is generated when an order is placed either through purchasing hardware **710**, accepting a subscription to personalized sound management application software **706**, or both. In at least one exemplary embodiment, the purchase process is web based allowing consumer **702** to purchase from a client system via a communication path such as the internet or communication network.

FIG. **8** is a diagram illustrating registering a new device that includes personalized sound management applications in accordance with at least one exemplary embodiment. A new device or unit is received by a customer **802**. The manufacturer has loaded the preordered personalized sound management applications chosen by customer **802** into the unit. Typically, customer **802** is going to want to try the unit shortly after receiving it (e.g., the unit is operational for a predetermined period of time **804**, for example 1 week). In at least one exemplary embodiment, customer **802** can try the unit for a predetermined time period **804**. In general, the time period **804** (for example, 15-30 minutes) is long enough for customer **802** to get a feel for the unit but is not a useful length of time. Furthermore, the unit will notify customer **802** through a transducer on the unit that they must register the device and that the unit will not be usable after the predetermined time period. Note that in at least one exemplary embodiment the customer would have the opportunity to demo certain features (**806**) not purchased.

In at least one exemplary embodiment, a website **810** is a portal to register the unit purchased by customer **802**. Website **810** can have a web page devoted to registering new devices to simplify the process. Customer **802** may log in (if an account already exists) or provide personal information related to the registering process. A database **812** is accessed that includes both customer and order information in one or more databases. In at least one exemplary embodiment, the unit is in communication with the device manufacturer server **814** through website **810** or coupled thereto through a customer system.

Verification **816** verifies that all information is correct and that there are no pending issues **818** with a corrective action identified. The verification process **816** can checks things like device serial number, features and applications ordered by customer **802**, personal/financial information. Once verification **816** is complete, it is determined at step **817** whether to register the device. Step **817** proceeds to step **820** if there are no pending issues **818**. Registration **820** registers the unit to the owner after verification **816** is complete.

FIG. **9** is a diagram illustrating enabling a device in accordance with at least one exemplary embodiment. In general, registration **902** links customer information to a device as disclosed in FIG. **8**. The registration process includes a comprehensive legally-compliant, state-specific Informed Consent system for collecting and storing the Informed Consent of users.

In at least one exemplary embodiment, the device will have at least one microphone. In the process of registration **902** the customer voice is recorded by the device. The customer voice can be stored on the device and to the customer database. The customer voice can be used for a number of applications including voice verification to use the device thereby acting as a deterrent for others to use or steal the device.

As mentioned in FIG. **8** the unit or device can be enabled for a predetermined time period. Prior to enabling the new device, a contract **904** is provided for customer review. The contract outlines the terms of use for using the device and that the product had been certified through a rigorous testing process. In at least one exemplary embodiment, liability coverage may be provided to the customer if the contract is accepted. Having the liability coverage in conjunction with the certification process is powerful in building consumer confidence about personalized sound management.

At step **905**, it is determined whether the contract is accepted. The new device is not enabled **906** if the customer does not accept contract **904**. The new device is enabled **908** if the customer accepts contract **904**. In at least one exemplary embodiment, the registration and enabling of the unit is through a client system coupled to the business server. Thus, the unit is enabled remotely.

FIG. **10** is a diagram illustrating updating a unit or device in accordance with at least one exemplary embodiment. The device is enabled for use. In general, instructions or an operational video may be provided for a user to get acquainted with the device. Even with this help, a device may have so many features and applications that the user could get overwhelmed or frustrated trying to understand and operate the unit. In some cases, a user may not want even try to learn how to operate all the features and initially start out with the application that provides significant utility to the user. The user may never address learning how to use all the capabilities of the device. Moreover, misuse of a device can lead to dangerous operating conditions that could cause a serious or harmful situation.

Acclimation **1002** is a process to ensure that a user of a device appreciates the entire feature set but more particularly, enables the features in a way that ensures proper usage in a safe and structured manner. In at least one exemplary embodiment, acclimation **1002** comprises two components, a learning module and a reminder module. The learning module is a system that "teaches" the user of the device the

functional components of the device. In at least one exemplary embodiment, the learning module may incorporate a learning system that evaluates the user in the domain of a particular competency before certain functions or features of the device are enabled. For example, features of the device are enabled sequentially, either automatically after the user has utilized a particular function for a predetermined time (thereby showing competency in using the feature) or following a user competency evaluation, which can be invoked either manually (when the user is confident in using the feature) or automatically.

The reminder module may or may not be used in acclimation **1002**. The reminder serves to remind the user of the correct usage of features and also serves to remind the user of other features on the device which the user may not have used in a given time period. In at least one exemplary embodiment an evaluation is invoked based on a predetermined time period. The evaluation may be for a single function or feature or a combination of different functions. The predetermined time period before evaluating can vary depending on the function. Alternatively, the evaluation may be invoked based on a particular recent event, such as a software upgrade, or a detected change in user usage. If the user passes the evaluation, the evaluation may be repeated, the relevant learning mode for the corresponding function to which the users competency was evaluated may be repeated, or the corresponding function to which the users competency was evaluated may be disabled. Thus, acclimation **1002** allows a user to learn the device at a friendly pace, ensures that the user does know how to use a feature, and protects the user from using the device in a manner that could be harmful.

The device can be coupled **1004** from a client system to the business server to update software on the device or purchase new hardware and software. As disclosed hereinabove, the user information is checked to determine if there are any issues that need to be rectified (e.g. missed payment, user does not match to device, etc. . . .). In the event that the issues cannot be rectified the device is disabled in a step **1006**. In at least one exemplary embodiment, the user information, device, and personalized sound management applications correlate. The server checks for updates **1008** for the device and downloads updates to the device. The user goes through a similar process as described in FIGS. **7A-7B** for a hardware or software purchase **1010** including agreeing to a contract to subscribe and contract to terms of use as described in FIG. **9**.

FIG. **11** is a diagram illustrating a device for implementing personalized sound management in accordance with at least one exemplary embodiment. The device is generally indicated as an earpiece that partially seals or seals a user's ear canal **1124** and is constructed and operates in accordance with at least one exemplary embodiment of the invention. As illustrated, the earpiece comprises an electronic housing unit **1100** and a sealing unit **1108**. The earpiece depicts an electro-acoustical assembly for an in-the-ear acoustic assembly, as it would typically be placed in an ear canal **1124** of a user **1130**. The earpiece can be an in the ear earpiece, behind the ear earpiece, receiver in the ear, partial-fit device, or any other suitable earpiece type. The earpiece can partially or fully occlude ear canal **1124**, and is suitable for use with users having healthy or abnormal auditory functioning.

The earpiece includes an Ambient Sound Microphone (ASM) **1120** to capture ambient sound, an Ear Canal Receiver (ECR) **1114** to deliver audio to an ear canal **1124**, and an Ear Canal Microphone (ECM) **1106** to capture and assess a sound exposure level within the ear canal **1124**. The earpiece can partially or fully occlude the ear canal **1124** to provide various degrees of acoustic isolation. In at least one exemplary embodiment, the assembly is designed to be inserted into the user's ear canal **1124**, and to form an acoustic seal with the walls of the ear canal **1124** at a location between the entrance to the ear canal **1124** and the tympanic membrane **1126** (or ear drum). In general, such a seal is typically achieved by means of a soft and compliant housing of sealing unit **1108**.

Sealing unit **1108** is an acoustic barrier having a first side corresponding to ear canal **1124** and a second side corresponding to the ambient environment. In at least one exemplary embodiment, sealing unit **1108** includes an ear canal microphone tube **1112** and an ear canal receiver tube **1110**. Sealing unit **1108** creates a closed cavity of approximately 5 cc between the first side of sealing unit **1108** and the tympanic membrane **1126** in ear canal **1124**. As a result of this sealing, the ECR (speaker) **1114** is able to generate a full range bass response when reproducing sounds for the user. This seal also serves to significantly reduce the sound pressure level at the user's eardrum **1126** resulting from the sound field at the entrance to the ear canal **1124**. This seal is also a basis for a sound isolating performance of the electro-acoustic assembly.

In at least one exemplary embodiment and in broader context, the second side of sealing unit **1108** corresponds to the earpiece, electronic housing unit **1100**, and ambient sound microphone **1120** that is exposed to the ambient environment. Ambient sound microphone **1120** receives ambient sound from the ambient environment around the user.

Electronic housing unit **1100** houses system components such as a microprocessor **1116**, memory **1104**, battery **1102**, ECM **1106**, ASM **1120**, ECR **1114**, and user interface **1122**. Microprocessor **1116** (or processor **1116**) can be a logic circuit, a digital signal processor, controller, or the like for performing calculations and operations for the earpiece. Microprocessor **1116** is operatively coupled to memory **1104**, ECM **1106**, ASM **1120**, ECR **1114**, and user interface **1122**. A wire **1118** provides an external connection to the earpiece. Battery **1102** powers the circuits and transducers of the earpiece. Battery **1102** can be a rechargeable or replaceable battery.

In at least one exemplary embodiment, electronic housing unit **1100** is adjacent to sealing unit **1108**. Openings in electronic housing unit **1100** receive ECM tube **1112** and ECR tube **1110** to respectively couple to ECM **1106** and ECR **1114**. ECR tube **1110** and ECM tube **1112** acoustically couple signals to and from ear canal **1124**. For example, ECR **1114** outputs an acoustic signal through ECR tube **1110** and into ear canal **1124** where it is received by the tympanic membrane **1126** of the user of the earpiece. Conversely, ECM **1106** receives an acoustic signal present in ear canal **1124** though ECM tube **1112**. All transducers shown can receive or transmit audio signals to a processor **1116** that undertakes audio signal processing and provides a transceiver for audio via the wired (wire **1118**) or a wireless communication path.

The earpiece can actively monitor a sound pressure level both inside and outside an ear canal **1124** and enhance spatial and timbral sound quality while maintaining supervision to ensure safe sound reproduction levels. The earpiece in various embodiments can conduct listening tests, filter sounds in the environment, monitor warning sounds in the environment, present notification based on identified warn-

ing sounds, maintain constant audio content to ambient sound levels, and filter sound in accordance with a Personalized Hearing Level (PHL).

The earpiece can generate an Ear Canal Transfer Function (ECTF) to model the ear canal **1124** using ECR **1114** and ECM **1106**, as well as an Outer Ear Canal Transfer function (OETF) using ASM **1120**. For instance, the ECR **1114** can deliver an impulse within the ear canal **1124** and generate the ECTF via cross correlation of the impulse with the impulse response of the ear canal **1124**. The earpiece can also determine a sealing profile with the user's ear to compensate for any leakage. It also includes a Sound Pressure Level Dosimeter to estimate sound exposure and recovery times. This permits the earpiece to safely administer and monitor sound exposure to the ear.

In at least one exemplary embodiment, the earpiece has a number of sonic signatures stored in memory. ASM **1120** is providing acoustic information from the ambient environment to processor **1116**. Processor **1116** analyses the acoustic information for a sound similar to the sonic signature. Once identified, the earpiece will provide a response to the sound based on the application. In a first exemplary embodiment, the earpiece will reduce music or telephone call (or the dominant source of sound being provided by the earpiece) and amplify the identified signal (ambulance or police car) thereby notifying the user of the approaching vehicle. In a second exemplary embodiment, the earpiece will tell the user (through a synthesized voice) that an ambulance or police car is approaching including the direction of the vehicle. The earpiece can also provide the identified signal with the voice warning. Other variations are possible.

Conversely, the earpiece can perform the opposite operation. The earpiece can identify a signal similar to the sonic signature and then attenuate it before providing it through ECR **1114**. For example, the user of the earpiece is a gun enthusiast. The user downloads a sonic signature related to a gun shot. The earpiece upon identifying the sound of the gun shot would attenuate the portion of the acoustic information provided by ASM **1120** similar to the sonic signature of the gun shot while allowing other signals to come through. Thus, the user could engage in a conversation at the gun range with the gun shot sounds attenuated while passing the conversation through the earpiece thereby protecting his ear from the loud sounds in this environment and being able to hear the conversation with more clarity.

In at least one exemplary embodiment, the earpiece can manually or automatically record, measure sound pressure levels, attach metadata (including time stamp and geocode), and upload the information when a communication path is present to a sound database. The earpiece is capable of running personalized sound management software disclosed herein. Moreover, hardware ingredients such as the transducers (ECR **1114**, ASM **1120**, and ECM **1106**), processor **1116**, and sealing unit **1108** are provided to manufacturers as disclosed in FIG. **3** for allowing a variety of companies to manufacture devices of their own earpiece designs. It should be noted that although an earpiece is used as an example of a personalized sound management device the components can be used in other communication devices and sound devices to personalize control of the sound.

In at least one exemplary embodiment, sealing section **1108** is a replaceable unit. Sealing section **1108** can pull out and be replaced as a unit. Sealing section **1108** performance can degrade over time due to particulate build up. There may also be sanitary or health reasons for replacing sealing section **1108** periodically. In at least one exemplary embodiment, sealing section **1108** replacement parts can be provided as part of a periodic subscription fee to a user, purchased over the counter in a store, or purchased through a web environment.

FIG. **12** is a block diagram of a device for implementing personalized sound management in accordance with at least one exemplary embodiment. A power supply **1205** powers components of the earpiece including microprocessor/DSP **1206** (or processor **1206**) and a data communication system **1216**. As illustrated, the earpiece can include the processor **1206** operatively coupled through a data communication system **1216** to an ASM **1210**, an ECR **1212**, and ECM **1208**. Data communication system **1216** can include one or more Analog to Digital Converters and Digital to Analog Converters (DAC). The processor **1206** can utilize computing technologies such as a microprocessor, Application Specific Integrated Chip (ASIC), and/or digital signal processor (DSP) with associated Random Access Memory (RAM) **1202** and Read Only Memory **1204**. Other memory types such as Flash, non-volatile memory, SRAM, DRAM or other like technologies can be used for storage with processor **1206**. The processor **1206** can also include a clock to record a time stamp.

In general, a data communication system **1216** is a communication pathway to components of the earpiece and components external to the earpiece. The communication link can be wired or wireless. In at least one exemplary embodiment, data communication system **1216** is configured to communicate with ECM assembly **1208**, ASM assembly **1210**, visual display **1218**, and user control interface **1214** of the earpiece. As shown, user control interface **1214** can be wired or wirelessly connected. In at least one exemplary embodiment, data communication system **1216** is capable of communication to devices exterior to the earpiece such as the user's mobile phone **1232**, a second earpiece **1222**, and a portable media player **1228**. Portable media player **1228** can be controlled by a manual user control **1230**.

The user's mobile phone includes a mobile phone **1232** communication system **1224**. A microprocessor **1226** is operatively coupled to mobile phone communication system **1224**. As illustrated multiple devices can be wirelessly connected to one another such as an earpiece **1220** worn by another person to the user's mobile phone **1232**. Similarly, the user's mobile phone **1232** can be connected to the data communication system **1216** of the earpiece as well as the second earpiece **1222**. This connection would allow one or more people to listen and respond to a call on the user's mobile phone **1232** through their respective earpieces.

As illustrated, a data communication system **1216** can include a voice operated control (VOX) module to provide voice control to one or more subsystems, such as a voice recognition system, a voice dictation system, a voice recorder, or any other voice related processor. The VOX module can also serve as a switch to indicate to the subsystem a presence of spoken voice and a voice activity level of the spoken voice. The VOX can be a hardware component implemented by discrete or analog electronic components or a software component. In one arrangement, the processor **1206** can provide functionality of the VOX by way of software, such as program code, assembly language, or machine language.

ROM **1204** can be used to store personalized sound management applications to minimize the possibility of modification and tampering of the code. The RAM **1202** can also store program instructions for execution on the processor **1206** as well as captured audio processing data. For instance, memory RAM **1202** and ROM **1204** can be off-

chip and external to the processor **1206** and include a data buffer to temporarily capture the ambient sound and the internal sound, and a storage memory to save from the data buffer the recent portion of the history in a compressed format responsive to a directive by the processor. The data buffer can be a circular buffer that temporarily stores audio sound at a current time point to a previous time point. It should also be noted that the data buffer can in one configuration reside on the processor **1206** to provide high speed data access. The storage memory can be non-volatile memory such as SRAM to store captured or compressed audio data. The non-volatile memory could also be used to store sonic signatures.

Data communication system **1216** can include an audio interface operatively coupled to the processor **1206** and the VOX to receive audio content, for example from portable media player **1228**, cell phone **1232**, or any other communication device, and deliver the audio content to the processor **1206**. The processor **1206** responsive to detecting voice-operated events from the VOX can adjust the audio content delivered to the ear canal of the user of the earpiece. For instance, the processor **1206** (or the VOX of data communication system **1216**) can lower a volume of the audio content responsive to detecting an event such as a sonic signature for transmitting the acute sound to the ear canal of the user. The processor **1206** by way of the ECM **1208** can also actively monitor the sound exposure level inside the ear canal and adjust the audio to within a safe and subjectively optimized listening level range based on voice operating decisions made by the VOX of data communication system **1216**.

The earpiece and data communication system **1216** can further include a transceiver that can support singly or in combination any number of wireless access technologies including without limitation Bluetooth™, Wireless Fidelity (WiFi), Worldwide Interoperability for Microwave Access (WiMAX), and/or other short or long range communication protocols. The transceiver can also provide support for dynamic downloading and uploading over-the-air to the earpiece. It should be noted also that next generation access technologies also can be applied to the present disclosure.

Data communication system **1216** can also include a location receiver that utilizes common technology such as a common GPS (Global Positioning System) receiver that can intercept satellite signals and therefrom determine a location fix of the earpiece and provide a geocode as an identifier for a recording or measurement such as sound pressure level.

The power supply **1205** can utilize common power management technologies such as replaceable batteries, supply regulation technologies, and charging system technologies for supplying energy to the components of the earpiece and to facilitate portable applications. A motor (not shown) can be a single supply motor driver coupled to the power supply **1205** to improve sensory input via haptic vibration. As an example, the processor **1206** can direct the motor to vibrate responsive to an action, such as a detection of a warning sound or an incoming voice call.

The earpiece can further represent a single operational device or a family of devices configured in a master-slave arrangement, for example, a mobile device and an earpiece. In the latter embodiment, the components of the earpiece can be reused in different form factors for the master and slave devices.

FIG. **13** is a diagram of a communication device **1302** or earpiece **1310** configured to provide sonic signatures to sonic signature database **1308** in accordance with at least one exemplary embodiment. Collecting a large number of sounds around the world is a daunting task. As mentioned previously, no group or business entity would have the ability to acoustically map the world on a continuous basis. In at least one exemplary embodiment, the collection of sonic signatures is achieved by mobilizing as many people as possible by making it simple to capture and provide a sound for sonic signature database **1308**. This is achieved by adapting a common device having a potential of reaching billions of people for manually or automatically capturing sonic signatures and providing them to database **1308**.

In at least one exemplary embodiment, communication device **1302** is a mobile communication device having a microphone for receiving sound. Examples of a communication device **1302** are a phone, cell phone, PDA, computer, two way radio, smart phone, and earpiece. Earpiece **1310** includes a microphone for capturing sound and the circuitry disclosed in FIG. **12**. Earpiece **1310** is operably configured for recording sound and measuring sound pressure levels. The acoustic information received from the microphone of earpiece **1310** is recorded to memory residing in earpiece **1310** and tagged with metadata including a time stamp and geocode. The sound pressure level (SPL) is measured from the microphone signal through analog or digital signal processing typically before any audio processing occurs within earpiece **1310**. The SPL measurement of this recorded event is associated to the stored recording and metadata. Similarly, communication device **1302** is adapted for capturing sound **1312** including recording, measuring sound pressure level, storing, and tagging with metadata (including a time stamp and geocode). In at least one embodiment, communication device **1302** could have additional circuitry similar to that in FIG. **12** in the device specifically for generating a sonic signature database. Alternately, the circuitry within communication device **1302** can be adapted for recording sound and measuring sound pressure level. In particular, mechanical aspects of the communication device such as microphone placement, microphone porting, as well as electronic audio processing (automatic gain control, equalization, etc. . . .) is taken into account for ensuring an accurate sound pressure level measurement and recording.

In at least one exemplary embodiment, a user having communication device **1302** manually or automatically captures and provides a sonic signature to a sonic signature database **1308**. For example, a microphone on communication device **1302** is always enabled for receiving sound. The sound can be stored in a buffer. The sound in the buffer is analyzed and based on a variety of criteria can be configured to be provided to database **1308**. For example, criteria such as sound pressure level, time, frequency of sound, geographic location, or recognition of a sound (sonic signature detection) are but a few of the parameters that could be used to determine that the sound in the buffer is worthy of saving. Metadata is automatically attached such as a time stamp and geocode but the user can also add information. In at least one exemplary embodiment, a communication path **1304** is opened and a link is made to website **1306** and more particularly to database **1308** where the stored sounds can be automatically uploaded. In at least one exemplary embodiment, the sonic signature, sound pressure level, and metadata could be immediately sent if a communication path **1304** is available to save memory. Further communication between website **1308** and the user of communication device **1302** or earpiece **1310** can take place to edit, identify, describe, and format the provided sound **1312** at a more convenient time. It should be noted that video information that includes audio information can also be provided in

similar fashion as disclosed hereinabove. The audio information from the video can be used for sonic signature database **1308**.

Earpiece **1310** and communication device **1302** can be operably coupled together. A priority could be set up such that earpiece **1310** is the primary recorder of sound **1312** when enabled by the user. Earpiece **1310** can be used with other devices for example a portable media player. Earpiece **1310** can automatically or manually record, measure SPL, and tag metadata of sound **1312** as described hereinabove. The sonic signatures stored in earpiece **1310** could be sent to website **1306** and sonic signature database **1308** if earpiece **1310** is coupled to a communication path **1304** or through another device to which it is operably coupled that has a communication path. Alternately, the sonic signatures could be uploaded via website **1306** and sonic signature database **1308** at a more convenient time, for example a wired or wireless link to the user's personal computer at home, allowing the user to also provide additional metadata before providing the information. Thus, a common device has been provided that is adapted for capturing, storing, measuring SPL, adding metadata including a time stamp and geocode, and uploading the acoustic information to a database thereby including the broadest number of people across the largest geographic area for sound collection on a continuous basis.

FIG. **14** is a block diagram illustrating a cell phone **1404** capturing a sonic signature and providing the sonic signature to a database of sounds **1418** in accordance with at least one exemplary embodiment. Cell phone **1404** is enabled for capturing a sonic signature via an exclusive button or through an automatic process. In at least one exemplary embodiment, the user can select whether a sound is recorded, a sound pressure level measurement is recorded, or both are acquired. A default can be that both are acquired automatically.

A sound **1402** is received by a microphone on cell phone **1404** and stored in a buffer in a record sounds step **1406**. The sound in the buffer is analyzed and determined to be saved. The sound pressure level (SPL) of the sonic signature is measured or calculated in a measure SPL step **1408**. The user can also manually enter metadata **1410** via a keyboard to a metadata table or can enter vocal description in an attached audio stream. Metadata **1410** includes a time stamp and a geocode corresponding to the sonic signature.

In at least one exemplary embodiment, the sonic signature, sound pressure level, and metadata can be stored in memory **1412** that resides on cell phone **1404**. A queue of sonic signatures **1414** can be stored in memory **1412** for uploading at an appropriate time. The user can initiate uploading of the queue of sonic signatures **1414** to database of sounds **1418** when a communication path is completed. In at least one exemplary embodiment, cell phone **1404** can automatically connect **1416** to servers in database of sounds **1418** and upload queue of sonic signatures **1414** when a communication path is enabled. Although stored on database of sounds **1418**, there may be an iterative process to determine if the sonic signatures are in the correct format or are unique enough to be permanently stored. Thus, a large database of sounds **1418** can be collected world wide by an automatic process using a common device such as a cell phone that could not be accomplished by direct means. In at least one exemplary embodiment, the database of sounds **1418** is used in conjunction with personalized sound management applications configured to provide sonic signatures for identifying and providing a response to the identified sound.

To encourage retailers to actively engage and participate in selling Hearium Labs branded products, a business model has been developed based on an annuity revenue sharing methodology. Through this patent pending approach, for the first time, retailers, operators and other suppliers will be able to carry a single audio earpiece or other device in their stores that can be sold to a wide and deep range of consumers. Utilizing an "iPod/iTunes" approach, suppliers will earn profit off the sale of the hardware in store and Personalized Sound Management applications at and after the point of sale. As the consumer continues to personalize their earpiece or device over time, the supplier will earn residuals of up to 50% of the application revenues through a co-operative sharing program between them and Hearium Labs.

To accomplish this, Hearium Labs has enabled the hardware solution to work off of a webified environment that is being architected with commercial flexibility for consumer driven point of sale purchase and activation. This approach allows for the Personalized Sound Management applications to be remotely downloaded and activated on the hardware through any Internet equipped PC and web-based browser. Consumers will thus be able to "enhance" their devices by adding both purchased and subscription applications and personalize their experience with technology designed to acclimate devices to the wearer and their environment.

In general, a process has been provided that eliminates barriers for mass adoption of a new technology. The result is that the technology can be provided by a number of manufacturers thereby having ubiquitous availability at release. Universal compatibility is also provided by using the same hardware and software in each new product having personalized sound management. Certification ensures that each device is manufacturable and performs to specification. Manufacturers and consumers benefit because liability coverage may be provided. Consumers can adapt to the technology rapidly through an acclimation process.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

We claim:

1. A system comprising:

a user interface; and

an audio device comprising:

a microphone configured to measure ambient sound and generate a microphone signal;

a speaker configured to emit an audio signal;

a memory configured to store instructions;

an audio buffer configured to store at least a portion of the microphone signal;

a data buffer;

a processor operatively coupled to the memory, the processor operatively coupled to the audio buffer, the processor operatively coupled to the data buffer, wherein the processor is configured to execute the instructions to perform operations comprising:

receiving the microphone signal;

sending a portion of the microphone signal to the audio buffer;

analyzing the audio buffer for detecting a sonic signature;

notifying a user when the sonic signature is detected;

sending a modified microphone signal to the data buffer replacing or adding to previous data stored in the data buffer; and

sending a portion of the data stored in the data buffer, spanning a time period, to the speaker in response to a user request, wherein the user request is one of the sonic signature that is a voice command or a manual input from the user interface.

2. The system according to claim **1**, wherein the sonic signature is a voice command, and where the voice command is to replay audio.

3. The system according to claim **1**, wherein the time period is less than 30 minutes.

4. The system according to claim **1**, wherein the time period is less than 15 minutes.

5. The system according to claim **1**, wherein the audio device is wirelessly connected to an earpiece.

6. The system according to claim **5**, wherein the earpiece includes:

an ambient sound microphone; and

an ear canal receiver.

7. The system according to claim **6**, wherein the earpiece further includes:

an ear canal microphone.

8. The system according to claim **7**, wherein the operation of notifying the user sends a notification signal to the ear canal receiver.

9. The system according to claim **5** wherein the earpiece further includes:

a sealing section.

10. The system according to claim **1**, wherein the sonic signature detected is one of a siren or an alarm.

11. The system according to claim **10** wherein the user interface is a button.

12. The system according to claim **1**, wherein the time period is less than 1 minute.

* * * * *

JS 44 (Rev. 09/19)

CIVIL COVER SHEET

The JS 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. *(SEE INSTRUCTIONS ON NEXT PAGE OF THIS FORM.)*

I. (a) PLAINTIFFS

STATON TECHIYA, LLC

(b) County of Residence of First Listed Plaintiff _____
(EXCEPT IN U.S. PLAINTIFF CASES)

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DEFENDANTS

HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED

County of Residence of First Listed Defendant _____
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED.

Attorneys *(If Known)*

II. BASIS OF JURISDICTION *(Place an "X" in One Box Only)*

- ❒ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question *(U.S. Government Not a Party)*
- ❒ 2 U.S. Government Defendant
- ❒ 4 Diversity *(Indicate Citizenship of Parties in Item III)*

III. CITIZENSHIP OF PRINCIPAL PARTIES *(Place an "X" in One Box for Plaintiff and One Box for Defendant)*
(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	❒ 1	❒ 1	Incorporated *or* Principal Place of Business In This State	❒ 4	❒ 4
Citizen of Another State	❒ 2	❒ 2	Incorporated *and* Principal Place of Business In Another State	❒ 5	❒ 5
Citizen or Subject of a Foreign Country	❒ 3	❒ 3	Foreign Nation	❒ 6	❒ 6

IV. NATURE OF SUIT *(Place an "X" in One Box Only)*

Click here for: Nature of Suit Code Descriptions.

CONTRACT
- ❒ 110 Insurance
- ❒ 120 Marine
- ❒ 130 Miller Act
- ❒ 140 Negotiable Instrument
- ❒ 150 Recovery of Overpayment & Enforcement of Judgment
- ❒ 151 Medicare Act
- ❒ 152 Recovery of Defaulted Student Loans (Excludes Veterans)
- ❒ 153 Recovery of Overpayment of Veteran's Benefits
- ❒ 160 Stockholders' Suits
- ❒ 190 Other Contract
- ❒ 195 Contract Product Liability
- ❒ 196 Franchise

REAL PROPERTY
- ❒ 210 Land Condemnation
- ❒ 220 Foreclosure
- ❒ 230 Rent Lease & Ejectment
- ❒ 240 Torts to Land
- ❒ 245 Tort Product Liability
- ❒ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ❒ 310 Airplane
- ❒ 315 Airplane Product Liability
- ❒ 320 Assault, Libel & Slander
- ❒ 330 Federal Employers' Liability
- ❒ 340 Marine
- ❒ 345 Marine Product Liability
- ❒ 350 Motor Vehicle
- ❒ 355 Motor Vehicle Product Liability
- ❒ 360 Other Personal Injury
- ❒ 362 Personal Injury - Medical Malpractice

PERSONAL INJURY
- ❒ 365 Personal Injury - Product Liability
- ❒ 367 Health Care/ Pharmaceutical Personal Injury Product Liability
- ❒ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ❒ 370 Other Fraud
- ❒ 371 Truth in Lending
- ❒ 380 Other Personal Property Damage
- ❒ 385 Property Damage Product Liability

CIVIL RIGHTS
- ❒ 440 Other Civil Rights
- ❒ 441 Voting
- ❒ 442 Employment
- ❒ 443 Housing/ Accommodations
- ❒ 445 Amer. w/Disabilities - Employment
- ❒ 446 Amer. w/Disabilities - Other
- ❒ 448 Education

PRISONER PETITIONS

Habeas Corpus:
- ❒ 463 Alien Detainee
- ❒ 510 Motions to Vacate Sentence
- ❒ 530 General
- ❒ 535 Death Penalty

Other:
- ❒ 540 Mandamus & Other
- ❒ 550 Civil Rights
- ❒ 555 Prison Condition
- ❒ 560 Civil Detainee - Conditions of Confinement

FORFEITURE/PENALTY
- ❒ 625 Drug Related Seizure of Property 21 USC 881
- ❒ 690 Other

LABOR
- ❒ 710 Fair Labor Standards Act
- ❒ 720 Labor/Management Relations
- ❒ 740 Railway Labor Act
- ❒ 751 Family and Medical Leave Act
- ❒ 790 Other Labor Litigation
- ❒ 791 Employee Retirement Income Security Act

IMMIGRATION
- ❒ 462 Naturalization Application
- ❒ 465 Other Immigration Actions

BANKRUPTCY
- ❒ 422 Appeal 28 USC 158
- ❒ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ❒ 820 Copyrights
- ☒ 830 Patent
- ❒ 835 Patent - Abbreviated New Drug Application
- ❒ 840 Trademark

SOCIAL SECURITY
- ❒ 861 HIA (1395ff)
- ❒ 862 Black Lung (923)
- ❒ 863 DIWC/DIWW (405(g))
- ❒ 864 SSID Title XVI
- ❒ 865 RSI (405(g))

FEDERAL TAX SUITS
- ❒ 870 Taxes (U.S. Plaintiff or Defendant)
- ❒ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ❒ 375 False Claims Act
- ❒ 376 Qui Tam (31 USC 3729(a))
- ❒ 400 State Reapportionment
- ❒ 410 Antitrust
- ❒ 430 Banks and Banking
- ❒ 450 Commerce
- ❒ 460 Deportation
- ❒ 470 Racketeer Influenced and Corrupt Organizations
- ❒ 480 Consumer Credit (15 USC 1681 or 1692)
- ❒ 485 Telephone Consumer Protection Act
- ❒ 490 Cable/Sat TV
- ❒ 850 Securities/Commodities/ Exchange
- ❒ 890 Other Statutory Actions
- ❒ 891 Agricultural Acts
- ❒ 893 Environmental Matters
- ❒ 895 Freedom of Information Act
- ❒ 896 Arbitration
- ❒ 899 Administrative Procedure Act/Review or Appeal of Agency Decision
- ❒ 950 Constitutionality of State Statutes

V. ORIGIN *(Place an "X" in One Box Only)*

- ☒ 1 Original Proceeding
- ❒ 2 Removed from State Court
- ❒ 3 Remanded from Appellate Court
- ❒ 4 Reinstated or Reopened
- ❒ 5 Transferred from Another District *(specify)*
- ❒ 6 Multidistrict Litigation - Transfer
- ❒ 8 Multidistrict Litigation - Direct File

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing ***(Do not cite jurisdictional statutes unless diversity)***:
35 U.S.C. § 271

Brief description of cause:
Patent Infringement

VII. REQUESTED IN COMPLAINT:

❒ CHECK IF THIS IS A **CLASS ACTION** UNDER RULE 23, F.R.Cv.P.

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ❒ No

VIII. RELATED CASE(S) IF ANY

(See instructions): JUDGE _____ DOCKET NUMBER See attachment

DATE
July 25, 2023

SIGNATURE OF ATTORNEY OF RECORD
/s/ Steven J. Balick

FOR OFFICE USE ONLY

RECEIPT # _____ AMOUNT _____ APPLYING IFP _____ JUDGE _____ MAG. JUDGE _____

INSTRUCTIONS FOR ATTORNEYS COMPLETING CIVIL COVER SHEET FORM JS 44

Authority For Civil Cover Sheet

The JS 44 civil cover sheet and the information contained herein neither replaces nor supplements the filings and service of pleading or other papers as required by law, except as provided by local rules of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket sheet. Consequently, a civil cover sheet is submitted to the Clerk of Court for each civil complaint filed. The attorney filing a case should complete the form as follows:

I.(a) **Plaintiffs-Defendants.** Enter names (last, first, middle initial) of plaintiff and defendant. If the plaintiff or defendant is a government agency, use only the full name or standard abbreviations. If the plaintiff or defendant is an official within a government agency, identify first the agency and then the official, giving both name and title.

(b) **County of Residence.** For each civil case filed, except U.S. plaintiff cases, enter the name of the county where the first listed plaintiff resides at the time of filing. In U.S. plaintiff cases, enter the name of the county in which the first listed defendant resides at the time of filing. (NOTE: In land condemnation cases, the county of residence of the "defendant" is the location of the tract of land involved.)

(c) **Attorneys.** Enter the firm name, address, telephone number, and attorney of record. If there are several attorneys, list them on an attachment, noting in this section "(see attachment)".

II. **Jurisdiction.** The basis of jurisdiction is set forth under Rule 8(a), F.R.Cv.P., which requires that jurisdictions be shown in pleadings. Place an "X" in one of the boxes. If there is more than one basis of jurisdiction, precedence is given in the order shown below.
United States plaintiff. (1) Jurisdiction based on 28 U.S.C. 1345 and 1348. Suits by agencies and officers of the United States are included here.
United States defendant. (2) When the plaintiff is suing the United States, its officers or agencies, place an "X" in this box.
Federal question. (3) This refers to suits under 28 U.S.C. 1331, where jurisdiction arises under the Constitution of the United States, an amendment to the Constitution, an act of Congress or a treaty of the United States. In cases where the U.S. is a party, the U.S. plaintiff or defendant code takes precedence, and box 1 or 2 should be marked.
Diversity of citizenship. (4) This refers to suits under 28 U.S.C. 1332, where parties are citizens of different states. When Box 4 is checked, the citizenship of the different parties must be checked. (See Section III below**; NOTE: federal question actions take precedence over diversity cases.**)

III. **Residence (citizenship) of Principal Parties.** This section of the JS 44 is to be completed if diversity of citizenship was indicated above. Mark this section for each principal party.

IV. **Nature of Suit.** Place an "X" in the appropriate box. If there are multiple nature of suit codes associated with the case, pick the nature of suit code that is most applicable. Click here for: Nature of Suit Code Descriptions.

V. **Origin.** Place an "X" in one of the seven boxes.
Original Proceedings. (1) Cases which originate in the United States district courts.
Removed from State Court. (2) Proceedings initiated in state courts may be removed to the district courts under Title 28 U.S.C., Section 1441.
Remanded from Appellate Court. (3) Check this box for cases remanded to the district court for further action. Use the date of remand as the filing date.
Reinstated or Reopened. (4) Check this box for cases reinstated or reopened in the district court. Use the reopening date as the filing date.
Transferred from Another District. (5) For cases transferred under Title 28 U.S.C. Section 1404(a). Do not use this for within district transfers or multidistrict litigation transfers.
Multidistrict Litigation – Transfer. (6) Check this box when a multidistrict case is transferred into the district under authority of Title 28 U.S.C. Section 1407.
Multidistrict Litigation – Direct File. (8) Check this box when a multidistrict case is filed in the same district as the Master MDL docket.
PLEASE NOTE THAT THERE IS NOT AN ORIGIN CODE 7. Origin Code 7 was used for historical records and is no longer relevant due to changes in statue.

VI. **Cause of Action.** Report the civil statute directly related to the cause of action and give a brief description of the cause. **Do not cite jurisdictional statutes unless diversity.** Example: U.S. Civil Statute: 47 USC 553 Brief Description: Unauthorized reception of cable service

VII. **Requested in Complaint.** Class Action. Place an "X" in this box if you are filing a class action under Rule 23, F.R.Cv.P.
Demand. In this space enter the actual dollar amount being demanded or indicate other demand, such as a preliminary injunction.
Jury Demand. Check the appropriate box to indicate whether or not a jury is being demanded.

VIII. **Related Cases.** This section of the JS 44 is used to reference related pending cases, if any. If there are related pending cases, insert the docket numbers and the corresponding judge names for such cases.

Date and Attorney Signature. Date and sign the civil cover sheet.

CIVIL COVER SHEET ATTACHMENT

Related Cases

Case Name	Case Number	Court
Staton Techiya, LLC v. Samsung Electronics Co., Ltd. et al	23-0319-JRG-RSP	EDTX
Staton Techiya, LLC et al v. Samsung Electronics Co., Ltd. et al	21-0413-JRG-RSP	EDTX

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