PTO/SB/14 (06-07)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	PERS-0052-US
	Application Number	
Title of Invention	ACOUSTIC SEALING ANALYSIS SYSTEM	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Applicant Information:

Applicant 1 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
Dr.	John		Usher	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Beer	State/Province		Country of Residence [i]	GB

Citizenship under 37 CFR 1.41(b) [i] GB

Mailing Address of Applicant:

Address 1	1 Lion Villa Causeway		
Address 2	Devon UK		
City	Beer	State/Province	
Postal Code	EX12 3LB	Country [i]	GB

Applicant 2 Remove

Applicant Authority ◉ Inventor ○ Legal Representative under 35 U.S.C. 117 ○ Party of Interest under 35 U.S.C. 118

Prefix	Given Name	Middle Name	Family Name	Suffix
Dr.	John	P	Keady	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Boca Raton	State/Province	FL	Country of Residence [i]	US

Citizenship under 37 CFR 1.41(b) [i] US

Mailing Address of Applicant:

Address 1	21427 Town Lakes Drive #215		
Address 2			
City	Boca Raton	State/Province	FL
Postal Code	33486	Country [i]	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

Petitioners' Ex. 1006
Samsung et. al. v. Techiya
IPR2024-01015
Page 00001

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	PERS-0052-US
	Application Number	
Title of Invention	ACOUSTIC SEALING ANALYSIS SYSTEM	

☐ **An Address is being provided for the correspondence Information of this application.**			
Customer Number	71158		
Email Address	sgoldstein@personicslabs.com	Add Email	Remove Email

Application Information:

Title of the Invention	ACOUSTIC SEALING ANALYSIS SYSTEM		
Attorney Docket Number	PERS-0052-US	**Small Entity Status Claimed**	☒
Application Type	Nonprovisional		
Subject Matter			
Suggested Class (if any)		**Sub Class (if any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	15	**Suggested Figure for Publication (if any)**	9

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application has not been and will not be the subject of an application filed in another country, or under a multilateral agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Enter either Customer Number or complete the Representative Name section below. If both sections are completed the Customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ US Representative (37 CFR 11.9)
Customer Number	71158		

Domestic Priority Information:

This section allows for the applicant to claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c). Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78(a)(2) or CFR 1.78(a)(4), and need not otherwise be made part of the specification.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	non provisional of	61/098250	2008-09-19

Additional Domestic Priority Data may be generated within this form by selecting the **Add** button. Add

PTO/SB/14 (06-07)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	PERS-0052-US
	Application Number	
Title of Invention	ACOUSTIC SEALING ANALYSIS SYSTEM	

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Remove

Application Number	Country [i]	Parent Filing Date (YYYY-MM-DD)	Priority Claimed
			(•) Yes ( ) No

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Assignee Information:

Providing this information in the application data sheet does not substitute for compliance with any requirement of part 3 of Title 37 of the CFR to have an assignment recorded in the Office.

Assignee 1 Remove

If the Assignee is an Organization check here. [X]

Organization Name	Personics Holdings Inc.		
Mailing Address Information:			
Address 1	5100 Town Center Circle Tower 2, Suite 510		
Address 2			
City	Boca Raton	**State/Province**	FL
Country [i]		Postal Code	33486
Phone Number		Fax Number	
Email Address	sgoldstein@personicslabs.com		

Additional Assignee Data may be generated within this form by selecting the **Add** button. Add

Signature:

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18. Please see 37 CFR 1.4(d) for the form of the signature.

Signature	/John P. Keady/			Date (YYYY-MM-DD)	2009-09-09
First Name	John	Last Name	Keady	Registration Number	56389

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

CLAIMS

What is claimed is:

1. A device comprising:

a sealing section configured to seal a user's orifice, where the sealing section is configured to produce an acoustic seal between a first side of the sealing section and a second side of the sealing section;

a transducer configured to emit a test signal incident on the first side of the sealing section; and

a microphone configured to measure an acoustic signal incident on the first side of the sealing section, where the acoustic signal includes the test signal emitted from the transducer where the acoustic signal is compared to the test signal to determine if the sealing section is sealed.

2. The device according to claim 1, where the acoustic signal is compared to the test signal by calculating at least one of the cross correlation, the correlation and the coherence of the signals.

3. The device of claim 1, where the orifice is an ear canal and where the sealing section is configured to reduce acoustic energy passing through the sealing section between the first side of the sealing section and the second side of the sealing section when the sealing section is sealed.

4. The device of claim 1, further including a processor operatively coupled to the

transducer and operatively coupled to the microphone where the processor has been configured to compare the test signal to the acoustic signal to determine if the sealing section is sealed.

5. -The device of claim 2 where the sealing section has passed a sealing test when the cross-correlation is equal to or greater than a threshold value.

6. The device according to claim 5 where the threshold corresponds to an attenuation level of the sealing section.

7. The device according to claim 5 where an indication is provided to the user indicating the sealing section is improperly sealed if the cross-correlation is not equal to or greater than the threshold value.

8. A method of detecting sealing integrity of an earpiece comprising the steps of:

providing a test signal;

generating an acoustic signal corresponding to the test signal incident on an ear canal side of a sealing section;

converting the acoustic signal incident on a first side of the sealing section to an electrical signal; and

comparing the test signal to the electrical signal where the earpiece is sealed correctly when the comparison between the test signal and the electrical signal is above a threshold value.

9. The method of claim 8, where the step of comparing the test signal to the electrical signal includes calculating at least one of a cross-correlation, a correlation, and a coherence value between the two signals.

10. The method of claim 9 further including a step of using a single frequency tone to test sealing integrity of the earpiece.

11. The method according to claim 10, where the single frequency tone is less than 200Hz.

12. The method of claim 11 further including a step of filtering the electrical signal with a low pass filter having a cut-off frequency less than or equal to 10 Hertz greater than the single frequency tone for testing sealing integrity.

13. The method of claim 9 further including the steps of:

testing the sealing integrity of the earpiece when the sealing section is initially inserted in an ear canal of a user ; and

periodically testing the sealing integrity of the earpiece while in use by the user.

14. The method of claim 13 where the step of periodically testing the sealing integrity of the earpiece further includes the steps of:

initiating a first timing sequence;

comparing a time of the first timing sequence against a first predetermined time period;

retrieving audio content from a signal buffer when the time of the first timing sequence is greater than the first predetermined time period;

initiating a second timing sequence for a second predetermined time period;

calculating the RMS of the audio content;

comparing the RMS of the audio content to a RMS threshold where the test signal is mixed with the audio content for providing a modified test signal if the audio content RMS is less than the RMS threshold;

emitting the modified test signal; and

resetting the first and the second timing sequence.

15. The method of claim 14 where the step of calculating audio content RMS further includes a step of filtering the audio content with a low pass filter.

16. The method of claim 14 further including the steps of:

periodically retrieving audio content from the signal buffer after the second timing sequence has been intitiated;

calculating the RMS of the audio content;

comparing the RMS of the audio content to a RMS threshold where the test signal is mixed with the audio content for providing a modified test signal if the audio content RMS is less than the RMS threshold;

emitting the modified test signal; and

resetting the first and the second timing sequence.

17. The method of claim 15 further including the steps of:

comparing a time of the second timing sequence against a second predetermined time period;

mixing the test signal with audio content for providing a modified test signal when the time of the second timing sequence is greater than the second predetermined time period;

emitting the modified test signal; and

resetting the first and the second timing sequence.

18. A method of adjusting attenuation of an earpiece comprising the steps of:

relating cross-correlation of a test signal and a measured acoustic signal in an ear canal of a user to an attenuation level of a sealing section of the earpiece;

comparing the attenuation level of the sealing section of the earpiece to a minimum attenuation value; and

adjusting a pressure of the sealing section to meet the minimum attenuation value.

19. The method of claim 18 further including a step of increasing the pressure of the sealing section to raise the attenuation level of the sealing section of the earpiece.

20. The method of claim 18 further including a step of decreasing the pressure of the sealing section such that the attenuation level of the sealing section is equal to or greater than the minimum attenuation level to improve comfort to the user of the earpiece.

21. The method of claim 18 further including a step of limiting the sealing section to a predetermined maximum pressure level.

22. The method of claim 18 further including a step of adjusting the sealing section to meet the minimum attenuation level as a background noise level changes.

23. The method of claim 18 further including a step of adjusting the minimum attenuation level by the Ear-Canal Sound Level of the earphone device.

24. The method of claim 18 further including a step of adjusting the minimum attenuation level by the level of audio content reproduced with the earphone device.

25. A device comprising:

a sealing section configured to seal a user's orifice, where the sealing section is configured to produce an acoustic seal between a first side of the sealing section and a second side of the sealing section;

a transducer configured to generate a first acoustic signal incident on the first side of the sealing section; and

a first microphone configured to measure a second acoustic signal incident on the second side of the sealing section, where the second acoustic signal includes at least a portion of the first acoustic signal that has passed from the first side to the second side of the sealing section where the first acoustic signal is compared to the second acoustic signal to determine if the sealing section is sealed.

26. The device of claim 25, where the orifice is an ear canal and where the sealing section is configured to reduce acoustic energy passing through the sealing section between the first side of the sealing section and the second side of the sealing section when the sealing section is sealed.

27. The device of claim 25, further including a processor operatively coupled to the transducer and operatively coupled to the first microphone where the processor has been configured to compare the first acoustic signal to the second acoustic signal to determine if the sealing section is sealed.

28. The device according to claim 27 further including a second microphone operatively coupled to the processor and configured to measure the first acoustic signal.

29. The device according to claim 25, where the portion of the first acoustic signal is detected in the second acoustic signal and where the sealing section is improperly sealed if the detected portion of the first acoustic signal in the second acoustic signal is greater than a threshold.

30. The device according to claim 29 where the first and second acoustic signals are correlated to one another.

31. The device according to claim 30 where the sealing section is improperly sealed if a magnitude of peak of the correlation between the first and second acoustic signal is greater the threshold.

32. The device according to claim 31 where an indication is provided to the user indicating the sealing section is improperly sealed when the threshold is exceeded.

33. The device according to claim 29 where one of a frequency spectrum analysis, RMS levels, coherence, and cross-correlation is used to determine if

the second acoustic signal includes at least a portion of the first acoustic signal that has passed from the first side to the second side of the sealing section.

34. A method of detecting whether a sealing section of an earpiece is sealed comprising the steps of:

generating a first acoustic signal incident on a first side of the sealing section;

measuring a second acoustic signal incident on a second side of the sealing section, where the second acoustic signal includes at least a portion of the first acoustic signal that has passed from the first side to the second side of the sealing section; and

comparing the first acoustic signal to the second acoustic signal to determine if the sealing section is sealed.

35. The method of claim 34 further including the steps of:

detecting the portion of the first acoustic signal that has passed from the first side to the second side of the sealing section;

quantifying the amount of the portion of the first acoustic signal has passed from the first side to the second side of the sealing section; and

warning the user when the portion of the first acoustic signal that has passed from the first side to the second side of the sealing section exceeds a predetermined threshold.

36. The method of claim 35 further including a step of correlating the first acoustic signal to the second acoustic signal to provide a measure of the portion of the first acoustic signal that has passed from the first side to the second side of the sealing section.

37. The method of claim 34 further including a step of combining a test signal with audio content pleasant to the user of the earpiece to form the first acoustic signal.

38. The method of claim 37 further including the steps of:

analyzing audio content provided to the ear piece;

determining if a portion of the audio content contains a strong tonal component with a defined sense of musical pitch;

determining a fundamental frequency of the portion of the audio content containing the strong tonal component; and

generating the test signal corresponding to the fundamental frequency.

39. The method of claim 38 further including the steps of:

comparing the fundamental frequency with a lower and upper frequency range;

scaling the test signal by an integer multiple or division of the fundamental frequency; and

generating the test signal as a tone with at least one fundamental pitch and optionally further harmonics.

40. The method of claim 34 further including a step of providing a chirp signal as the first acoustic signal.

41. The method of claim 34 further including a step of providing white noise as the first acoustic signal.

42. The method of claim 34 further including a step of providing a Maximum Length Sequence (MLS) signal as the first acoustic signal.

43. A method of detecting whether a sealing section of an earpiece is sealed comprising the steps of:

generating a first acoustic signal incident on a first side of the sealing section;

measuring a second acoustic signal incident on a second side of the sealing section, where the second acoustic signal includes at least a portion of the first acoustic signal that has passed from the first side to the second side of the sealing section;

correlating the first acoustic and second acoustic signals; and

comparing the correlation to a threshold where the earpiece is sealed improperly if the threshold is exceeded.

44. The method of claim 43 further including the steps of:

generating a magnitude of peak from the correlation; and

comparing the magnitude of peak to a peak threshold where the earpiece is sealed improperly if the peak threshold is exceeded.

45. The method of claim 44 further including the steps of:

generating a lag-time of peak from the correlation;

determining if the lag-time of peak is within a time range; and

notifying a user of the earpiece that the earpiece is improperly sealed when both the peak threshold is exceeded and the lag-time peak is with the time range.

46. The method of claim 43 further including a step of generating the first acoustic signal comprising a chirp signal.

47. The method of claim 43 further including a step of generating the first acoustic signal comprising a low pass filtered white noise signal.

48. The method of claim 43 further including a step of generating the first acoustic signal comprising a Maximum Length Sequence (MLS) signal.

49. The method of claim 43 further including a step of combining a test signal with

audio content pleasant to the user of the earpiece to form the first acoustic signal.

50. The method of claim 44 further including a step of providing the test signal when the ambient noise is low.

51. The method of claim 44 further including a step of providing the test signal when the audio content is low.

52. The method of claim 49 further including the steps of:

analyzing audio content provided to the ear piece;

determining if a portion of the audio content contains a strong tonal component with a defined sense of musical pitch;

determining a fundamental frequency of the portion of the audio content containing the strong tonal component; and

generating the test signal corresponding to the fundamental frequency.

53. The method of claim 52 further including the steps of:

comparing the fundamental frequency with a lower and upper frequency range;

scaling the test signal by an integer multiple or division of the fundamental frequency; and

generating the test signal as a tone with at least one fundamental pitch

and optionally further harmonics.

ABSTRACT

A test signal emitted by an earpiece is compared against the acoustic signal to determine if a sealing section of the earpiece is sealed properly. The degree of acoustic sealing is used to adjust the attenuation level of a sealing section of the earpiece or alert the user that the sealing section of the seal status.

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	ACOUSTIC SEALING ANALYSIS SYSTEM
First Named Inventor/Applicant Name:	John Usher
Filer:	John Patrick Keady
Attorney Docket Number:	PERS-0052-US

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	82	82
Utility Search Fee	2111	1	270	270
Utility Examination Fee	2311	1	110	110
Pages:				
Claims:				
Claims in excess of 20	2202	33	26	858
Independent claims in excess of 3	2201	3	110	330
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**1650**

Electronic Acknowledgement Receipt

EFS ID:	6035180
Application Number:	12555864
International Application Number:	
Confirmation Number:	1435
Title of Invention:	ACOUSTIC SEALING ANALYSIS SYSTEM
First Named Inventor/Applicant Name:	John Usher
Customer Number:	71158
Filer:	John Patrick Keady
Filer Authorized By:	
Attorney Docket Number:	PERS-0052-US
Receipt Date:	09-SEP-2009
Filing Date:	
Time Stamp:	11:07:11
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1650
RAM confirmation Number	7801
Deposit Account	504284
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	PERS-0052-US-ADS.pdf	747524 52755d49abe5a47608dbf730fe48f8a5cc43d5c5	no	4
Warnings:					
Information:					
2	Drawings-only black and white line drawings	PERS-0052-US-FIGS.pdf	1441839 b090cb8da44278ae95f01f0fae91729899a9bbff	no	15
Warnings:					
Information:					
3		PERS-0052-US-SPEC.pdf	314959 f92417f3c0a9e4ce501c0ed292378e578785cac6	yes	57

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	42
Claims	43	56
Abstract	57	57

Warnings:					
Information:					
4	Fee Worksheet (PTO-875)	fee-info.pdf	37781 a6ea89de84c6ed6946e63b6adadb3484eaac0c22	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2542103		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Acknowledgement Receipt

EFS ID:	6035180
Application Number:	12555864
International Application Number:	
Confirmation Number:	1435
Title of Invention:	ACOUSTIC SEALING ANALYSIS SYSTEM
First Named Inventor/Applicant Name:	John Usher
Customer Number:	71158
Filer:	John Patrick Keady
Filer Authorized By:	
Attorney Docket Number:	PERS-0052-US
Receipt Date:	09-SEP-2009
Filing Date:	
Time Stamp:	11:07:11
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1650
RAM confirmation Number	7801
Deposit Account	504284
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

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Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	PERS-0052-US-ADS.pdf	747524 52755d49abe5a47608dbf730fe48f8a5cc43d5c5	no	4
Warnings:					
Information:					
2	Drawings-only black and white line drawings	PERS-0052-US-FIGS.pdf	1441839 b090cb8da44278ae95f01f0fae91729899a9bbff	no	15
Warnings:					
Information:					
3		PERS-0052-US-SPEC.pdf	314959 f92417f3c0a9e4ce501c0ed292378e578785cac6	yes	57

Multipart Description/PDF files in .zip description

Document Description	Start	End
Specification	1	42
Claims	43	56
Abstract	57	57

Warnings:					
Information:					
4	Fee Worksheet (PTO-875)	fee-info.pdf	37781 a6ea89de84c6ed6946e63b6adadb3484eaac0c22	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2542103		

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

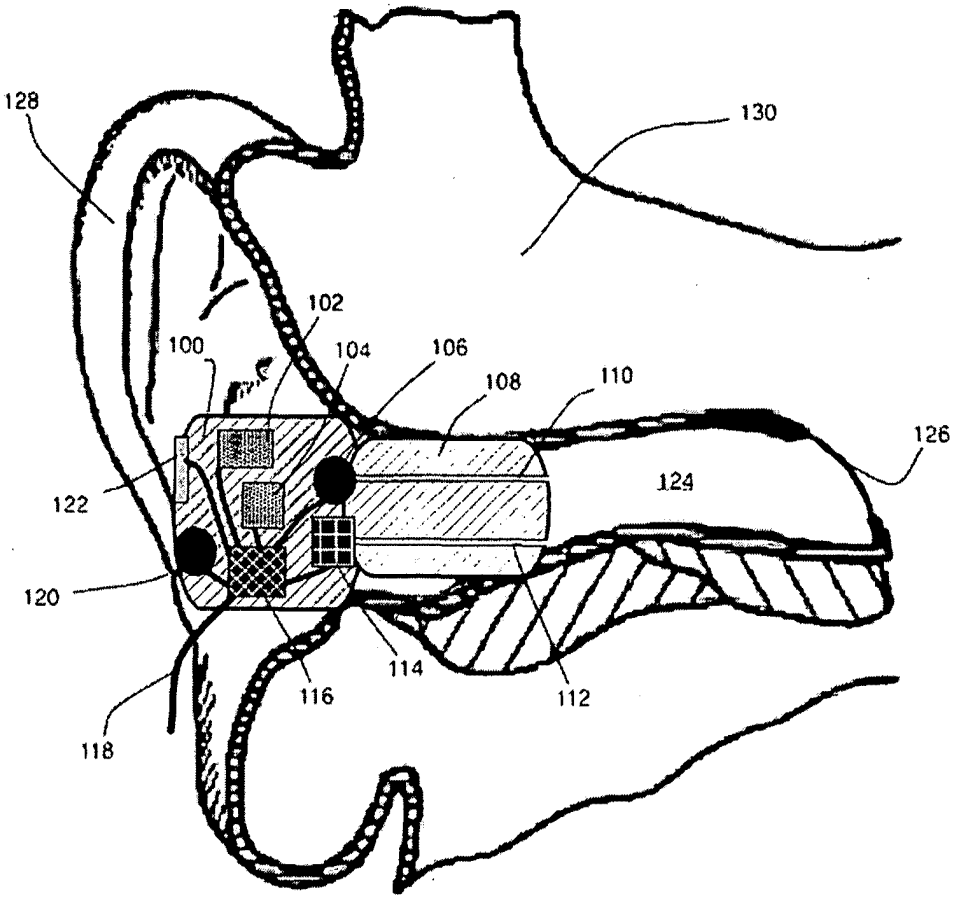
National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

FIG. 1



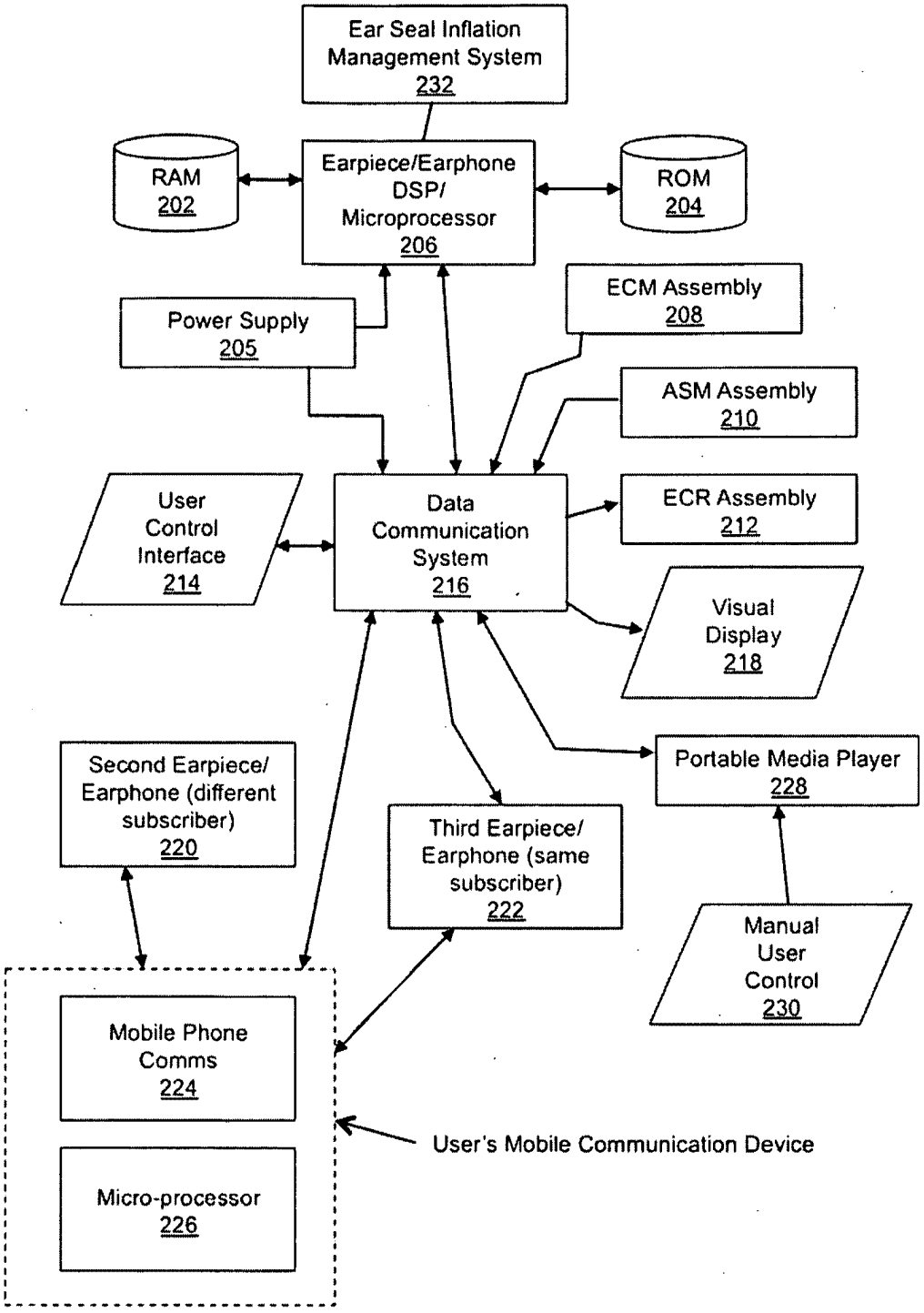

Ear Seal Inflation Management System 232
RAM 202
Earpiece/Earphone DSP/ Microprocessor 206
ROM 204
Power Supply 205
ECM Assembly 208
ASM Assembly 210
User Control Interface 214
Data Communication System 216
ECR Assembly 212
Visual Display 218
Second Earpiece/ Earphone (different subscriber) 220
Third Earpiece/ Earphone (same subscriber) 222
Portable Media Player 228
Manual User Control 230
Mobile Phone Comms 224
Micro-processor 226
User's Mobile Communication Device

FIG. 2

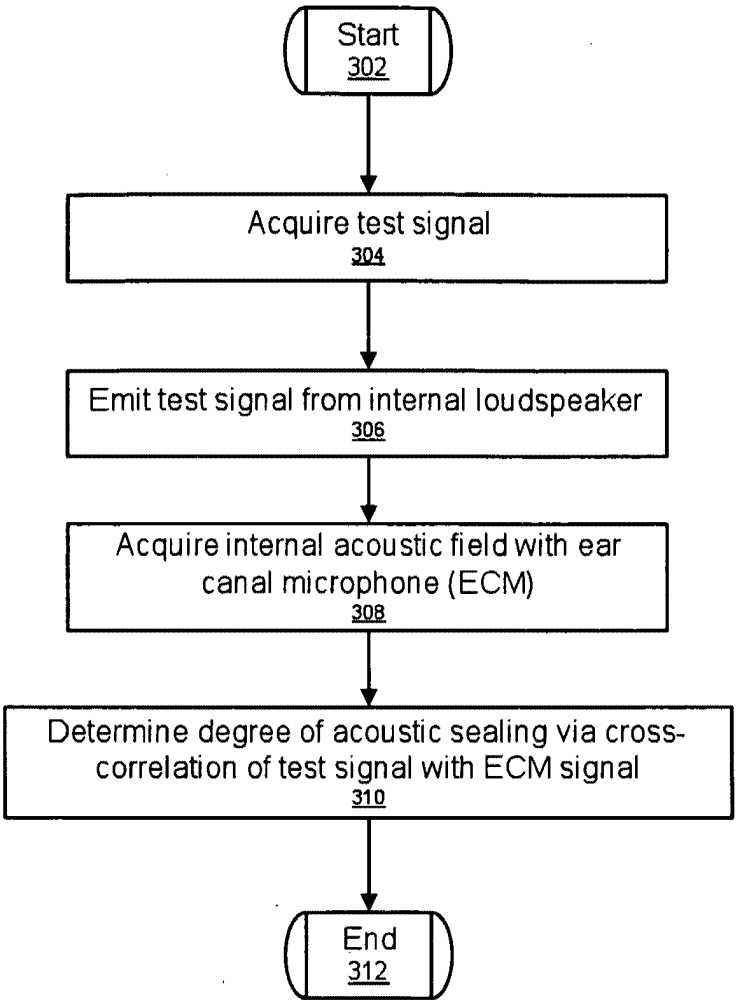

Start
302
Acquire test signal
304
Emit test signal from internal loudspeaker
306
Acquire internal acoustic field with ear canal microphone (ECM)
308
Determine degree of acoustic sealing via cross-correlation of test signal with ECM signal
310
End
312

FIG. 3

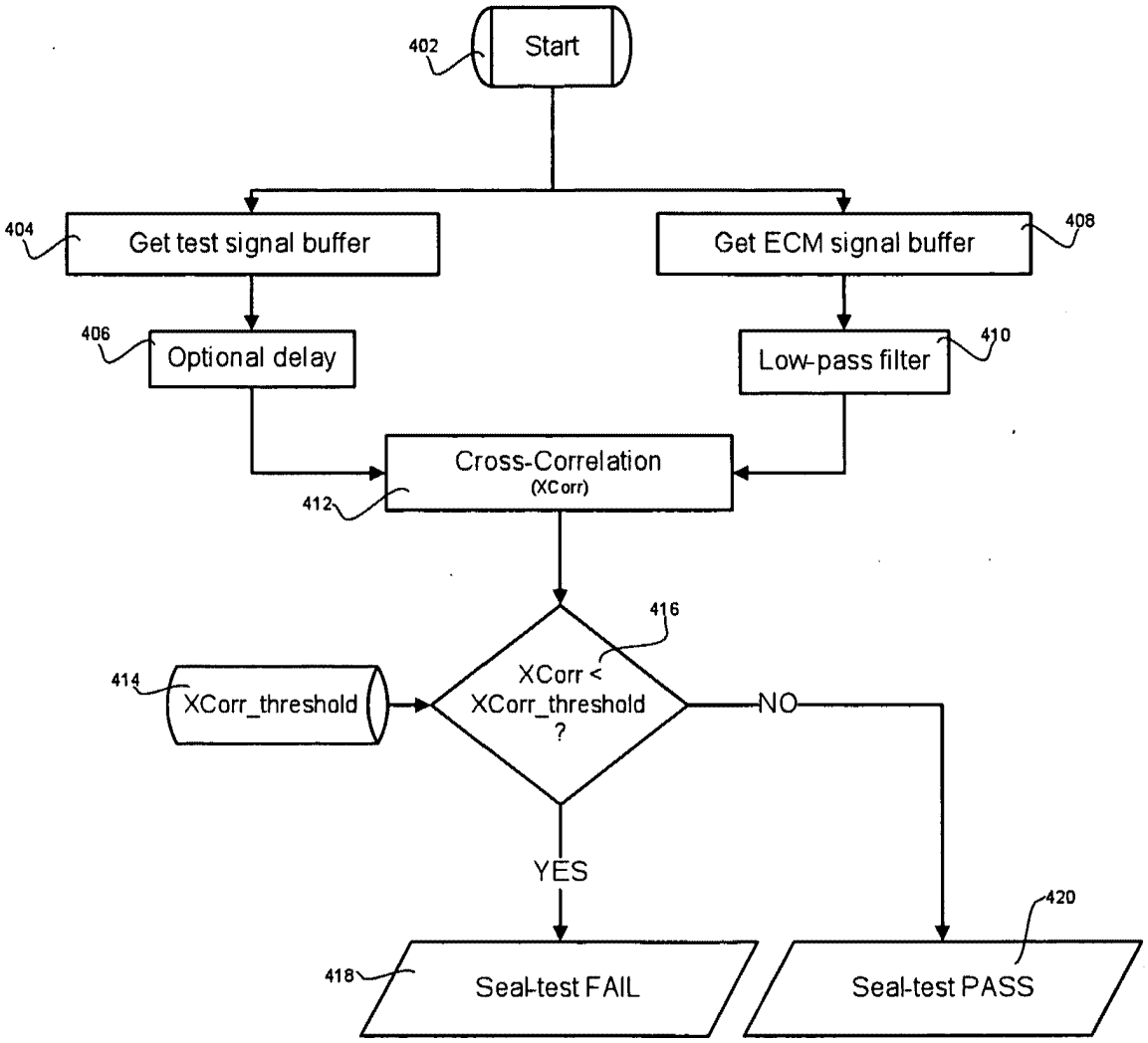

Start
402
Get test signal buffer
404
Get ECM signal buffer
408
Optional delay
406
Low-pass filter
410
Cross-Correlation
(XCorr)
412
XCorr_threshold
414
XCorr <
XCorr_threshold
?
416
NO
YES
Seal-test FAIL
418
Seal-test PASS
420

FIG. 4

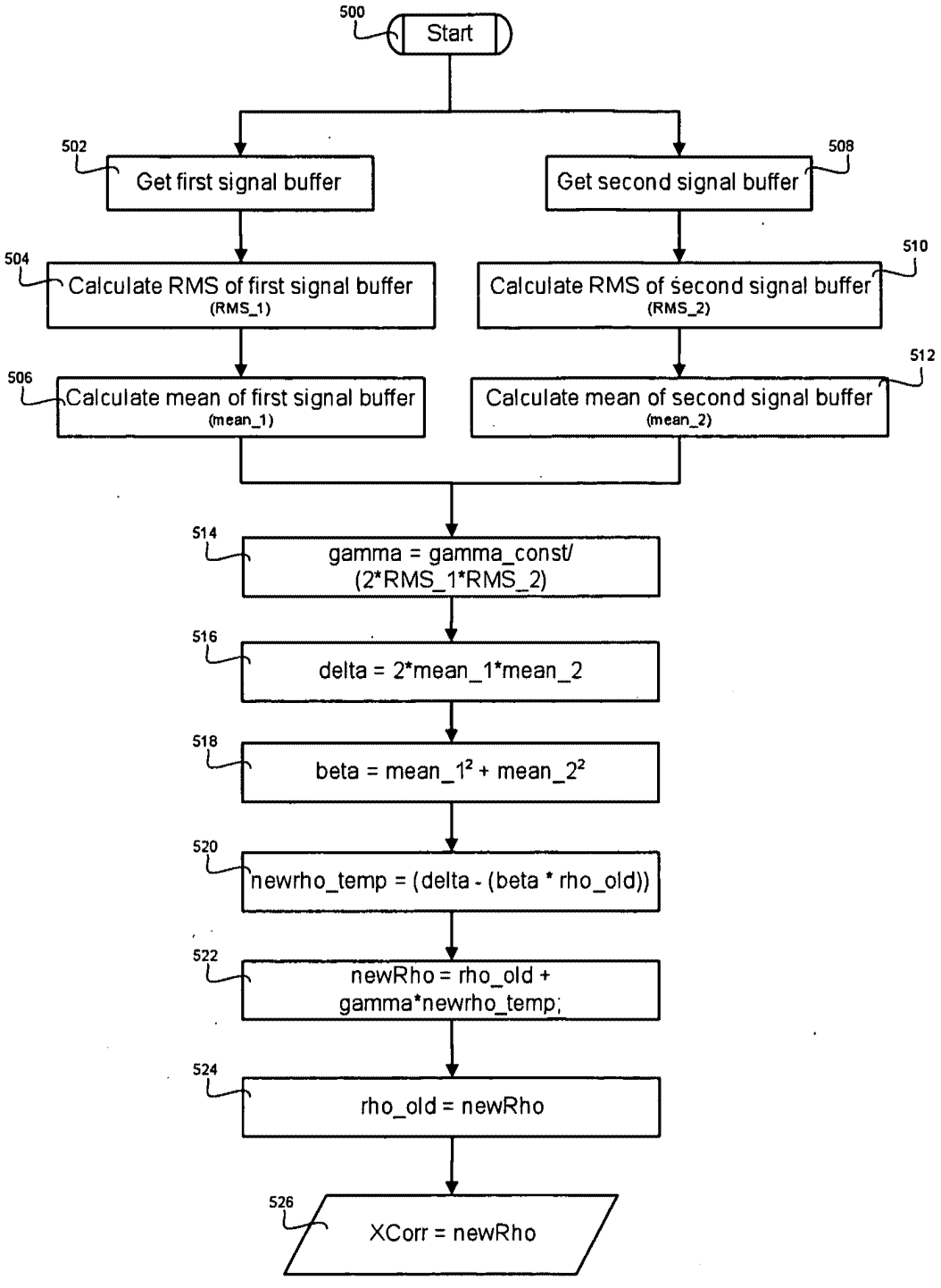

500
Start
502
Get first signal buffer
508
Get second signal buffer
504
Calculate RMS of first signal buffer
(RMS_1)
510
Calculate RMS of second signal buffer
(RMS_2)
506
Calculate mean of first signal buffer
(mean_1)
512
Calculate mean of second signal buffer
(mean_2)
514
gamma = gamma_const/
(2*RMS_1*RMS_2)
516
delta = 2*mean_1*mean_2
518
beta = mean_1² + mean_2²
520
newrho_temp = (delta - (beta * rho_old))
522
newRho = rho_old +
gamma*newrho_temp;
524
rho_old = newRho
526
XCorr = newRho

FIG.5

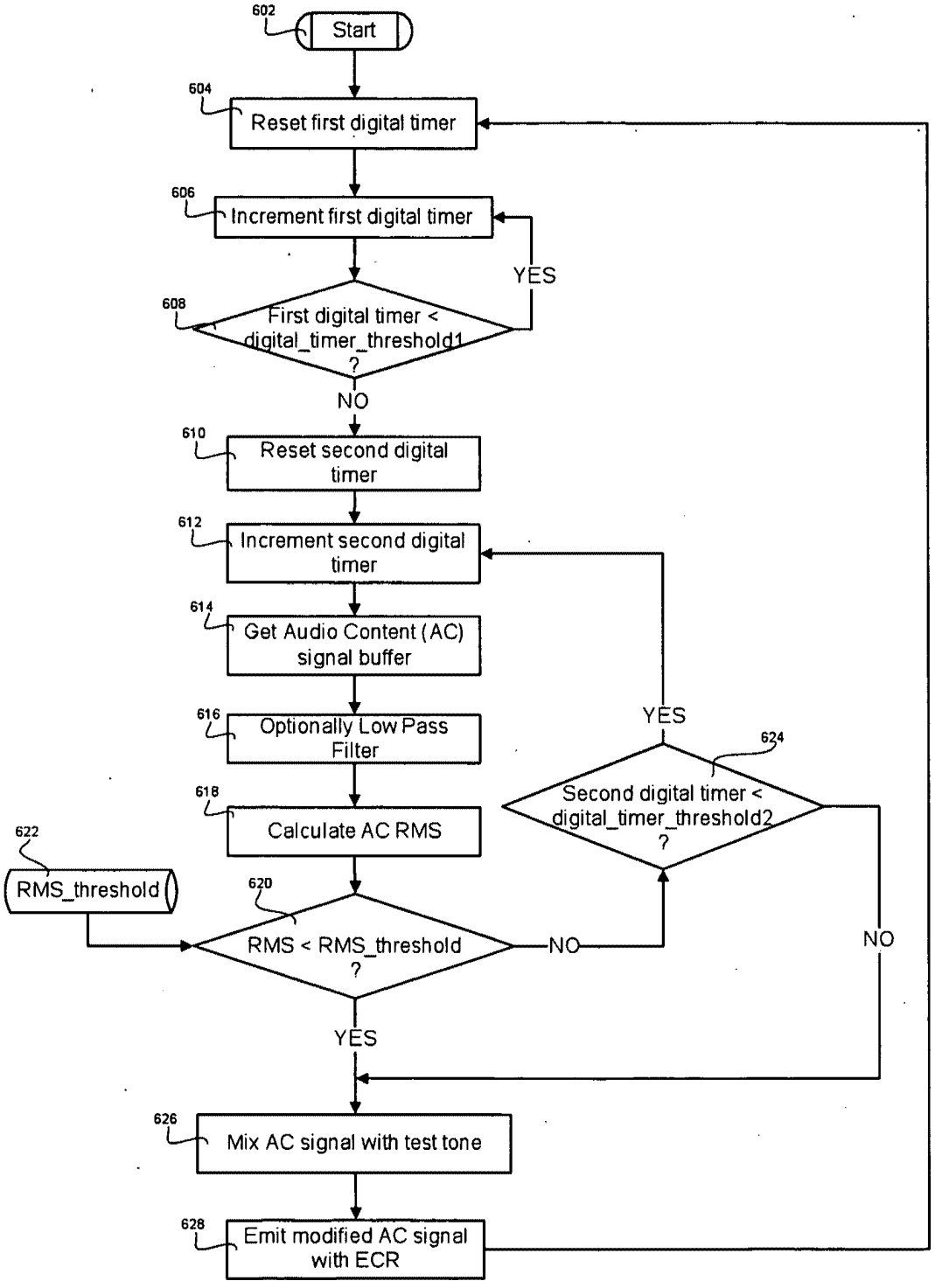

602
Start
604
Reset first digital timer
606
Increment first digital timer
YES
608
First digital timer < digital_timer_threshold1 ?
NO
610
Reset second digital timer
612
Increment second digital timer
614
Get Audio Content (AC) signal buffer
616
Optionally Low Pass Filter
618
Calculate AC RMS
622
RMS_threshold
620
RMS < RMS_threshold ?
NO
YES
624
Second digital timer < digital_timer_threshold2 ?
YES
NO
626
Mix AC signal with test tone
628
Emit modified AC signal with ECR

FIG. 6

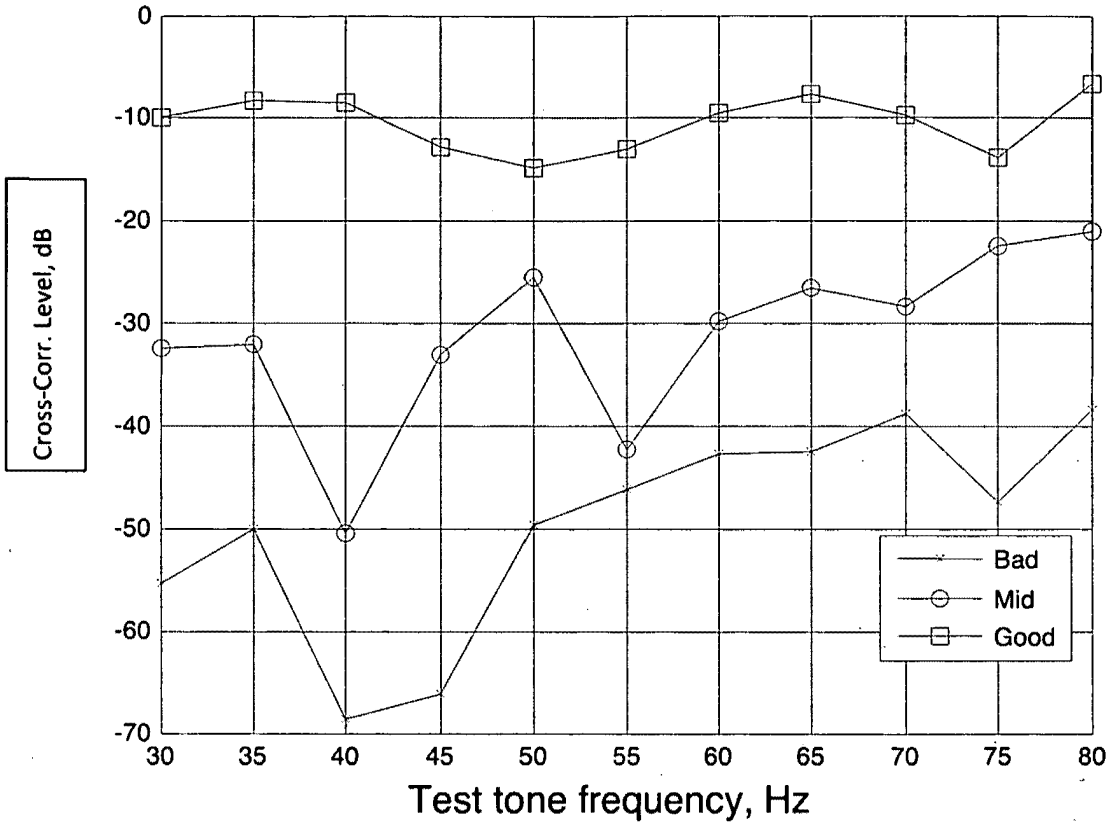

Cross-Corr. Level, dB
0
-10
-20
-30
-40
-50
-60
-70
30
35
40
45
50
55
60
65
70
75
80
Test tone frequency, Hz
Bad
Mid
Good

FIG. 7

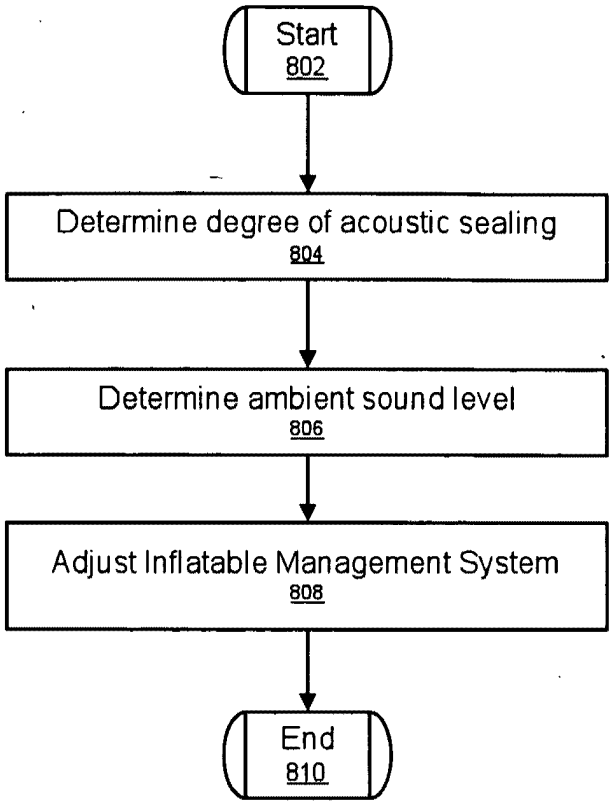

Start
802
Determine degree of acoustic sealing
804
Determine ambient sound level
806
Adjust Inflatable Management System
808
End
810

FIG. 8

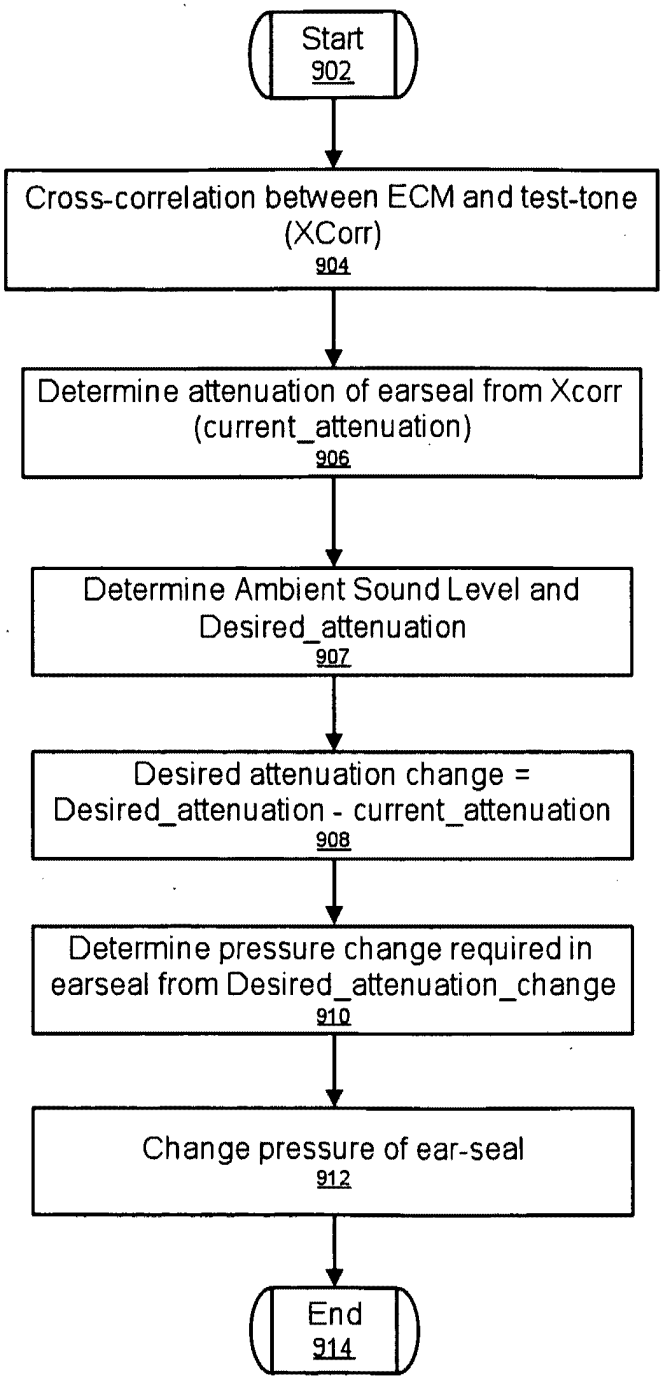

Start
902
Cross-correlation between ECM and test-tone (XCorr)
904
Determine attenuation of earseal from Xcorr (current_attenuation)
906
Determine Ambient Sound Level and Desired_attenuation
907
Desired attenuation change = Desired_attenuation - current_attenuation
908
Determine pressure change required in earseal from Desired_attenuation_change
910
Change pressure of ear-seal
912
End
914

FIG. 9

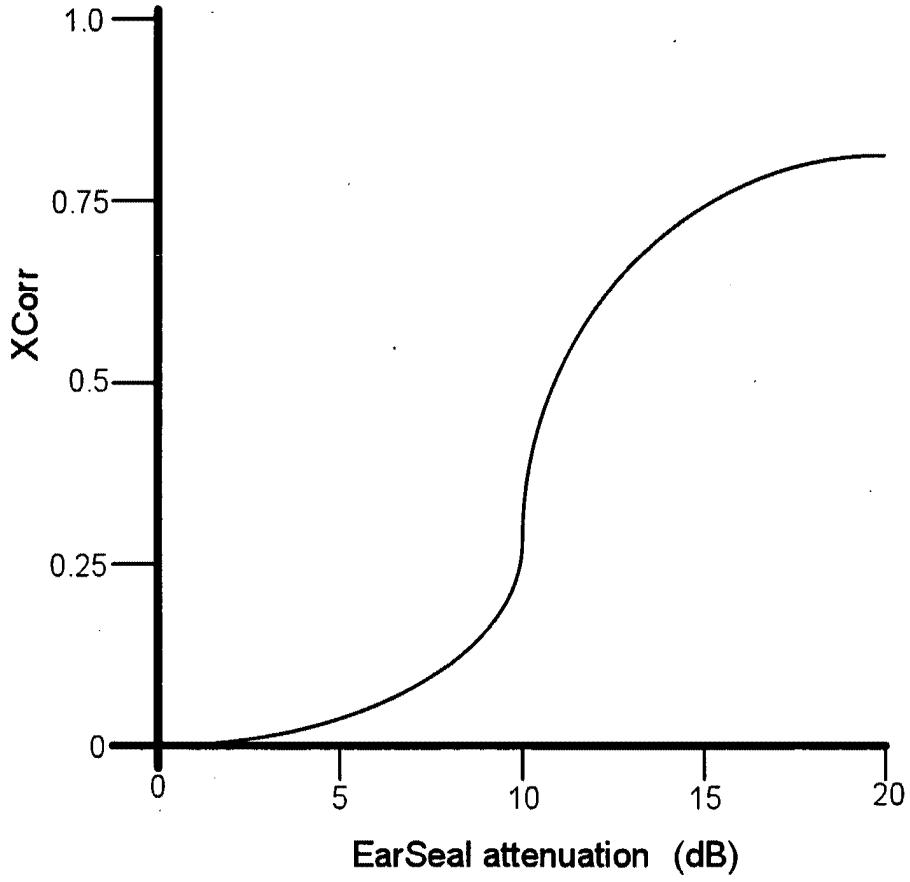


FIG. 10

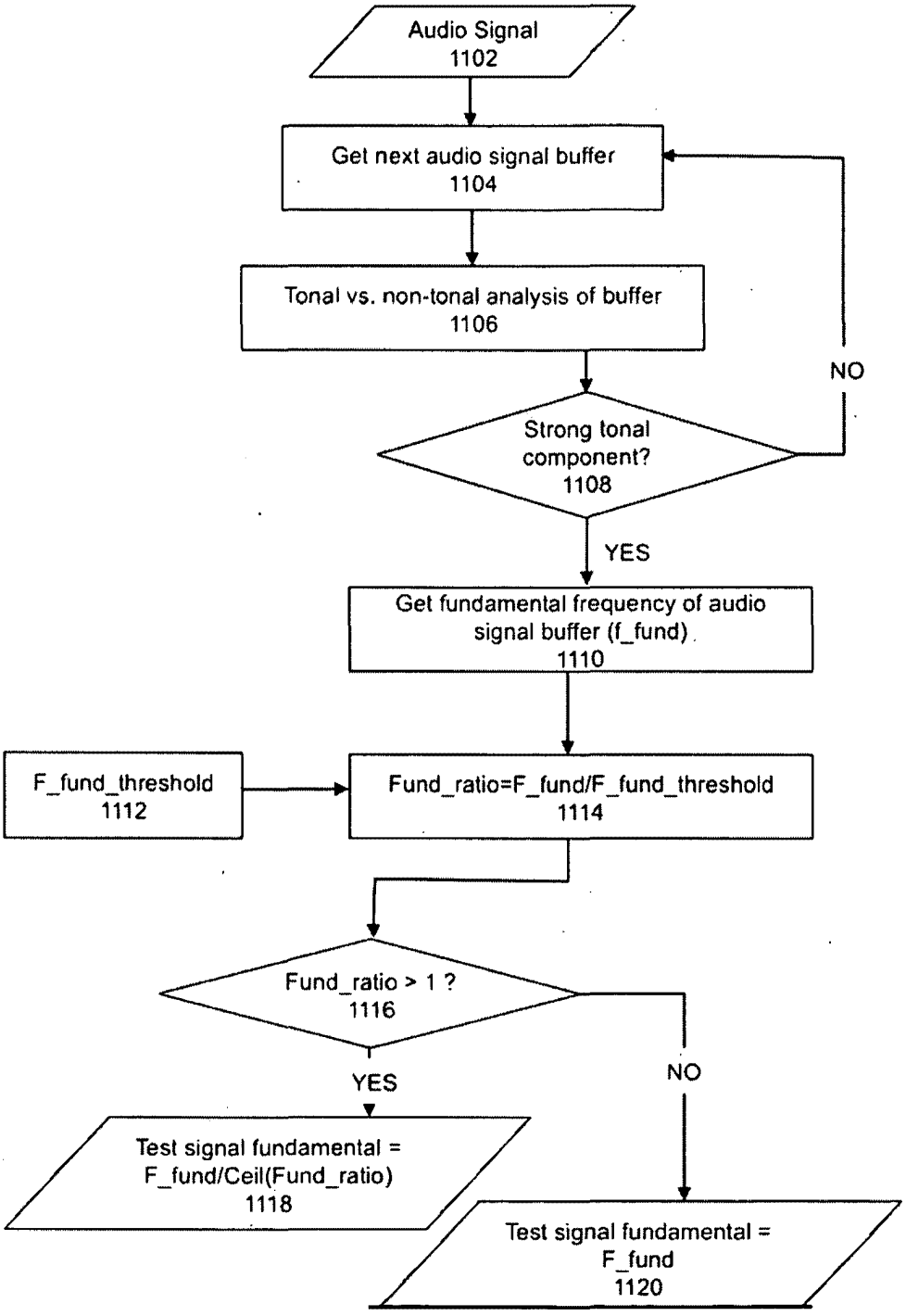

Audio Signal
1102
Get next audio signal buffer
1104
Tonal vs. non-tonal analysis of buffer
1106
Strong tonal component?
1108
NO
YES
Get fundamental frequency of audio signal buffer (f_fund)
1110
F_fund_threshold
1112
Fund_ratio=F_fund/F_fund_threshold
1114
Fund_ratio > 1 ?
1116
YES
NO
Test signal fundamental = F_fund/Ceil(Fund_ratio)
1118
Test signal fundamental = F_fund
1120

FIG. 11

Fig. 12

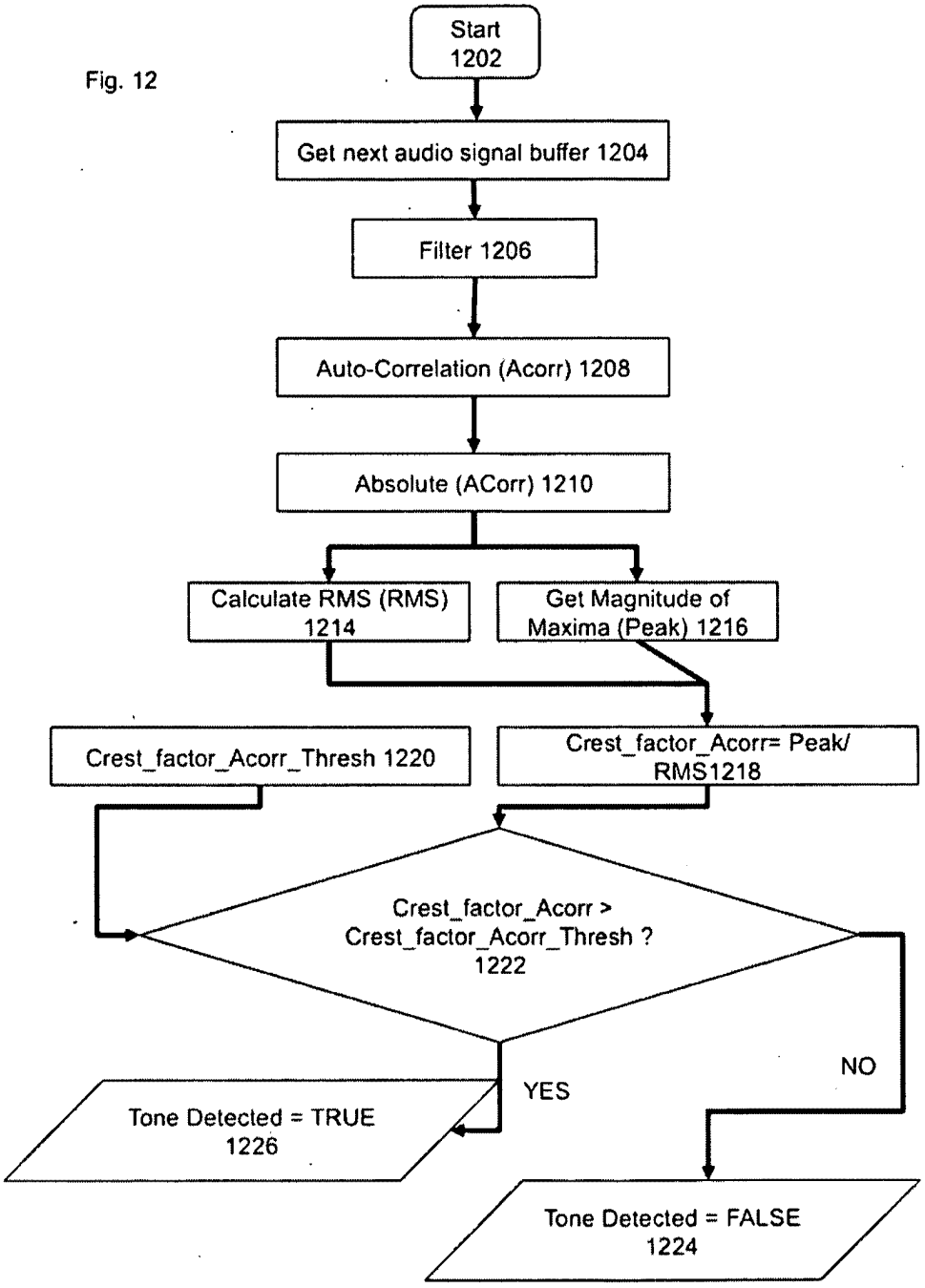

Start
1202
Get next audio signal buffer 1204
Filter 1206
Auto-Correlation (Acorr) 1208
Absolute (ACorr) 1210
Calculate RMS (RMS)
1214
Get Magnitude of
Maxima (Peak) 1216
Crest_factor_Acorr_Thresh 1220
Crest_factor_Acorr= Peak/
RMS1218
Crest_factor_Acorr >
Crest_factor_Acorr_Thresh ?
1222
YES
NO
Tone Detected = TRUE
1226
Tone Detected = FALSE
1224

Fig. 13

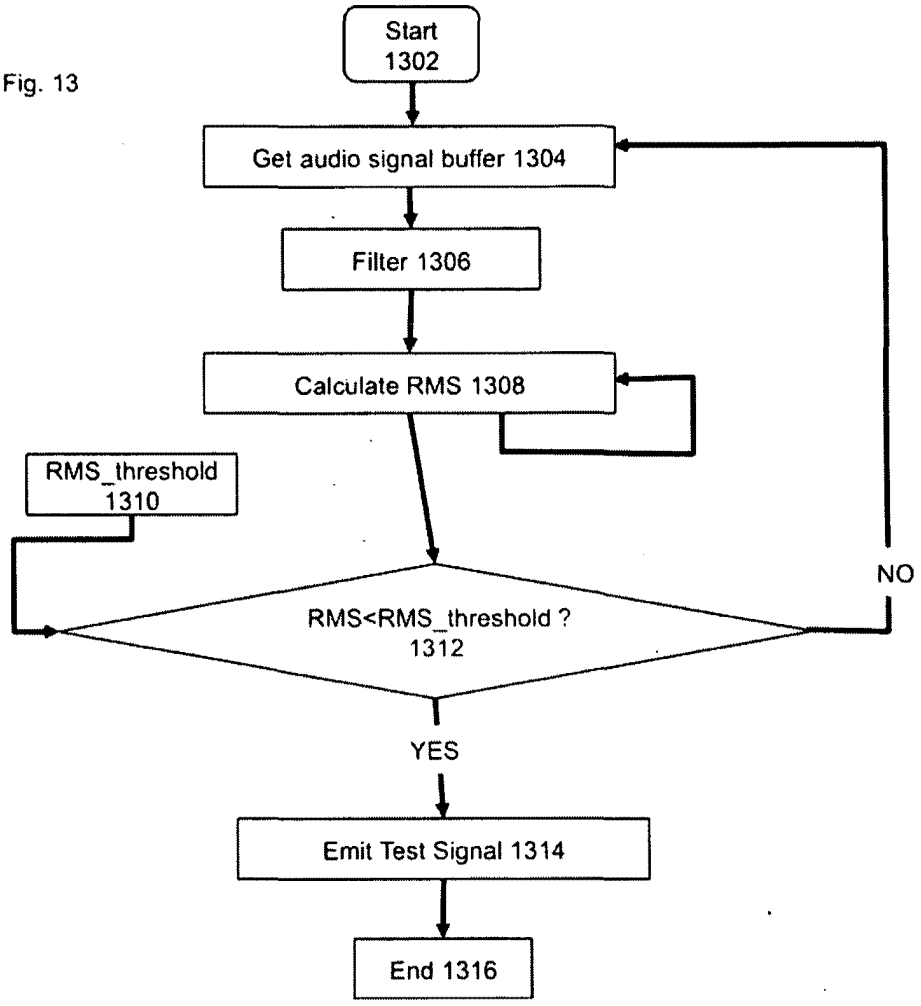

Start
1302
Get audio signal buffer 1304
Filter 1306
Calculate RMS 1308
RMS_threshold
1310
RMS<RMS_threshold ?
1312
NO
YES
Emit Test Signal 1314
End 1316

Fig. 14

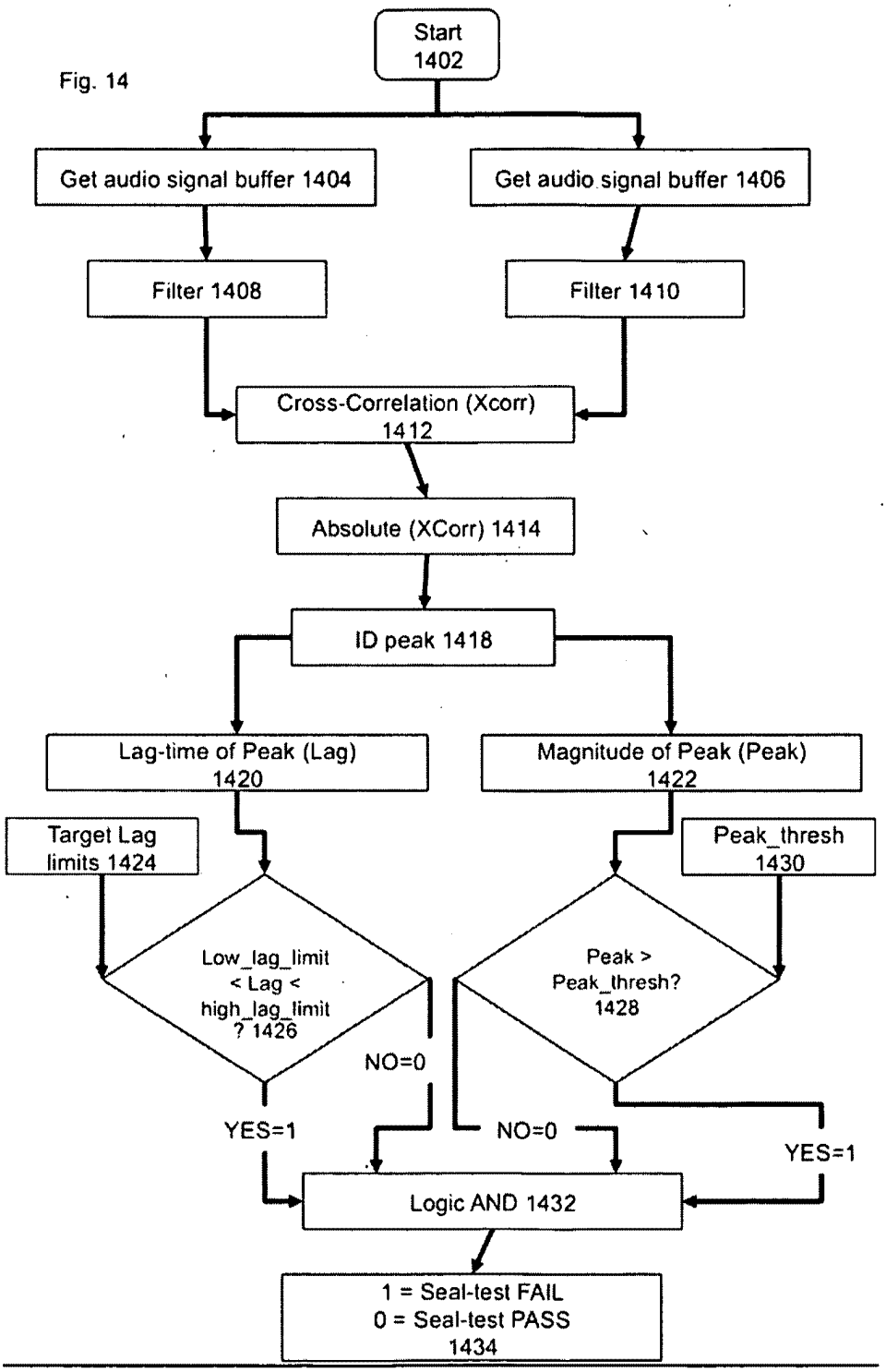

Start
1402
Get audio signal buffer 1404
Get audio signal buffer 1406
Filter 1408
Filter 1410
Cross-Correlation (Xcorr)
1412
Absolute (XCorr) 1414
ID peak 1418
Lag-time of Peak (Lag)
1420
Magnitude of Peak (Peak)
1422
Target Lag
limits 1424
Peak_thresh
1430
Low_lag_limit
< Lag <
high_lag_limit
? 1426
Peak >
Peak_thresh?
1428
NO=0
YES=1
NO=0
YES=1
Logic AND 1432
1 = Seal-test FAIL
0 = Seal-test PASS
1434

FIG. 15A

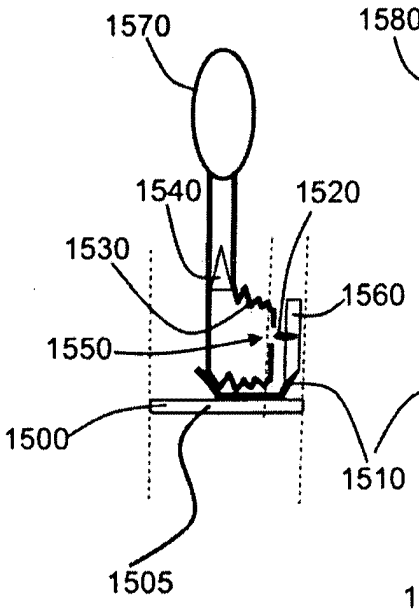


FIG. 15B

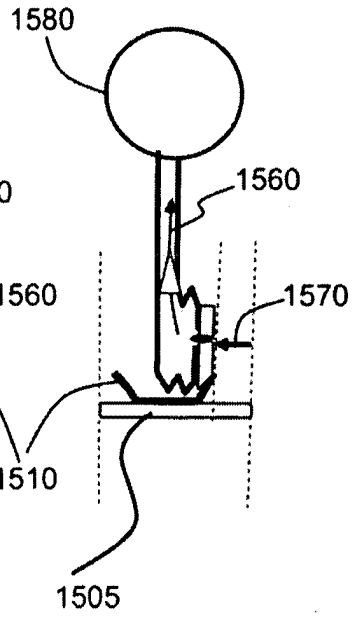
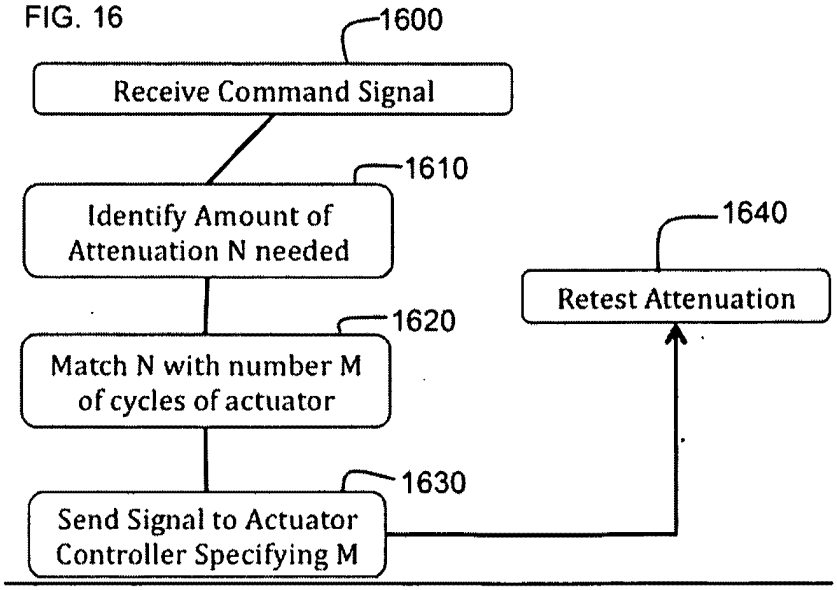


FIG. 16



APPLICATION FOR LETTERS PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

FOR:

ACOUSTIC SEALING ANALYSIS SYSTEM

By:
John Usher

John P. Keady

ACOUSTIC SEALING ANALYSIS SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. provisional patent application No. 61/098,250 filed 19 Sept. 2008. The disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to testing the seal of an orifice-inserted device, and more particularly, though not exclusively, to a device and method for determining if an earpiece is sealed correctly in an ear canal.

BACKGROUND

[0003] It can be difficult to communicate using an earpiece or earphone device in the presence of high-level background sounds. In many earpiece designs a transducer is placed near the ear canal opening. Ambient sound from the surrounding environment enters the ear canal with the audio content from the transducer. Environmental sounds such as traffic, construction, and nearby conversations can degrade the quality of the audio content.

[0004] Although audio processing technologies can adequately suppress noise, the earpiece is generally sound agnostic and cannot differentiate sounds. Thus, one method to prevent ambient sound from entering the ear is to seal or provide an acoustic barrier at the opening of the ear canal. Sealing minimizes ambient sound leakage into the ear canal, and under the correct conditions can provide a level of noise suppresion under high background noise conditions. Ceratin types

of acoustic software (e.g., communicationin in a noisy environment via an ear canal microphone) may require some minimum noise isolation from the ambient to provide adequate performance to the user. Additionally, user conditions may change substantially during the operation of the earpiece, and in some circumstances, the earpiece may become misaligned or may be fit incorrectly such that it is not sealed correctly. A method of seal detection is neede to optimize performance.

SUMMARY

[0005] Broadly stated, embodiments are directed to a device and method to determine if an earpiece is sealing within the design specification of the device.

[0006] In one embodiment, the device can include a sealing section forming an acoustic barrier between a first volume and a second volume. An ear canal receiver (ECR) can be configured to generate an acoustic signal in the first volume. An Ear Canal Microphone (ECM) in the first volume can be configured to measure the acoustic signal in the first volume. The first acoustic signal emitted by the ECR can be cross-correlated with the first acoustic signal detected with the ECM to determine if the sealing section is sealed properly.

[0007] At least one exemplary embodiment is directed to a method of detecting sealing integrity of an earpiece comprising the steps of: providing a test signal; generating an acoustic signal corresponding to the test signal incident on an ear canal side of a sealing section; converting the acoustic signal incident on a first side of the sealing section to an electrical signal; and cross-correlating the test

signal to the electrical signal where the earpiece is sealed correctly when a cross-correlation between the test signal and the electrical signal is above a threshold.

[0008] At least one exemplary embodiment is directed to a method of adjusting attenuation of an earpiece comprising the steps of: relating cross-correlation of a test signal and a measured acoustic signal in an ear canal of a user to an attenuation level of a sealing section of the earpiece; comparing the attenuation level of the sealing section of the earpiece to a minimum attenuation value; and adjusting a pressure of the sealing section to meet the minimum attenuation value.

[0009] At least one exemplary embodiment is directed to a device comprising: a sealing section configured to seal a user's orifice, where the sealing section is configured to produce an acoustic seal between a first side of the sealing section and a second side of the sealing section; a transducer configured to generate a first acoustic signal incident on the first side of the sealing section; and a first microphone configured to measure a second acoustic signal incident on the second side of the sealing section, where the second acoustic signal includes at least a portion of the first acoustic signal that has passed from the first side to the second side of the sealing section where the first acoustic signal is compared to the second acoustic signal to determine if the sealing section is sealed.

[0010]

[0011] Further areas of applicability of exemplary embodiments of the present invention will become apparent from the detailed description provided

hereinafter. It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Exemplary embodiments of present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0013] FIG. 1 is a diagram of an earpiece inserted in an ear canal in accordance with an exemplary embodiment;

[0014] FIG. 2 is a block diagram of optional components of an earpiece in accordance with an exemplary embodiment;

[0015] FIG. 3 is a flowchart of a method for checking an ear seal in accordance with an exemplary embodiment;

[0016] FIG. 4 is a flowchart to determine acoustic seal integrity of an earpiece in accordance with the exemplary embodiment.

[0017] FIG. 5 is a flowchart of a method to estimate the instantaneous cross-correlation between a first and second audio signal.

[0018] FIG. 6 is a flowchart to determine when to emit a test signal in accordance with an exemplary embodiment;

[0019] FIG. 7 is a graph illustrating different seal measurements in accordance with the present invention;

[0020] FIG. 8 is a block diagram for a method of adjusting the IMS system in accordance with at least one exemplary embodiment;

[0021] FIG. 9 is a block diagram for a method of adjusting IMS pressure in accordance with at least one exemplary embodiment;

[0022] FIG. 10 illustrates a sample relationship between EarSeal attenuation and XCorr in accordance with at least one exemplary embodiment;

[0023] FIG. 11 illustrates a flowchart of an exemplary method to determine a test signal fundamental;

[0024] FIG. 12 illustrates a flowchart of an exemplary embodiment to determine tonal presence in audio content;

[0025] FIG. 13 illustrates a flowchart of a method to determine when to emit the test signal;

[0026] FIG. 14 illustrates a flowchart of an exemplary method to determine acoustic seal integrity;

[0027] Figures 15A and B illustrates a method of varying the seal of an inflation system in accordance with at least one exemplary embodiment; and

[0028] Figure 16 illustrates the sending of a signal to an inflation controller upon detection of a seal fail to modify the seal pressure in accordance with at least one exemplary embodiment.

DETAILED DESCRIPTION

[0029] 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.

[0030] Exemplary embodiments are directed to or can be operatively used on various wired or wireless orifice inserted devices for example earpieces devices (e.g., earbuds, headphones, ear terminal, behind the ear devices or other acoustic devices as known by one of ordinary skill, and equivalents).

[0031] 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.

[0032] Additionally exemplary embodiments are not limited to earpieces, for example some functionality can be implemented on other systems with speakers and/or microphones for example computer systems, PDAs, Blackberrys, cell and mobile phones, and any other device that emits or measures acoustic energy. 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 examples Knowle's FG and EG series transducers.

[0033] 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.

[0034] In all of the examples illustrated and discussed herein, any specific values, for example the sound pressure level change, should be interpreted to be illustrative only and non-limiting. Thus, other examples of the exemplary embodiments could have different values.

[0035] Note that herein when referring to correcting or preventing an error or damage (*e.g.*, hearing damage), a reduction of the damage or error and/or a correction of the damage or error are intended.

[0036] At least one exemplary embodiment of the invention is directed to an earpiece for sealing or partially sealing an ear. **FIG. 1** is a diagram of an earpiece inserted in an ear canal 124 in accordance with at least one exemplary embodiment of the invention. As illustrated, the earpiece comprises an electronic housing unit 100 and a sealing unit 108. The earpiece depicts an electro-acoustical assembly for an in-the-ear acoustic assembly, as it would typically be placed in an ear canal 124 of a user 130. The earpiece is an in-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 the ear canal 124.

[0037] The earpiece includes an Ambient Sound Microphone (ASM) 120 to capture ambient sound, an Ear Canal Receiver (ECR) 114 to deliver audio to an ear canal 124, and an Ear Canal Microphone (ECM) 106 to capture and assess a sound exposure level within the ear canal 124. The earpiece can partially or fully

occlude the ear canal 124 to provide various degrees of acoustic isolation. The assembly is designed to be inserted into the user's ear canal 124, and to form an acoustic seal with the walls of the ear canal 124 at a location between the entrance to the ear canal 124 and the tympanic membrane (or ear drum) 126. In general, such a seal is typically achieved by means of a soft and compliant housing of the sealing unit 108. Additionally the sealing unit can be a pressurized expandable element that fills a portion of the available local space.

[0038] Sealing unit 108 is an acoustic barrier having a first side corresponding to ear canal 124 and a second side corresponding to the ambient environment. In at least one exemplary embodiment, sealing unit 108 includes an ear canal microphone tube 110 and an ear canal receiver tube 112. Sealing unit 108 creates a closed cavity of approximately 5cc or less between the first side of sealing unit 108 and the tympanic membrane 126 in ear canal 124. In at least one exemplary embodiment the sealing facilitates using the ECR (speaker) 114 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 resulting from the sound field at the entrance to the ear canal 124. This seal is also a basis for a sound isolating performance of the electro-acoustic assembly.

[0039] In at least one exemplary embodiment and in broader context, the second side of sealing unit 108 corresponds to the side adjacent to electronic housing unit 100. Ambient sound microphone 120 is housed in electronic

housing unit 100 and is exposed to the ambient environment for receiving sound from the ambient environment around the user.

[0040] The electronic housing unit 100 can include various system components such as a microprocessor 116, memory 104, battery 102, ECM 106, ASM 120, ECR, 114, and user interface 120, or these components can reside in a separate system or interface operatively connected. Microprocessor 116 (or processor 116) can be a logic circuit, a digital signal processor, controller, or the like for performing calculations and operations for the earpiece. Microprocessor 116 is operatively coupled to memory 104, ECM 106, ASM 120, ECR 114, and user interface 120. An optional wire 118 can provide an external connection to the earpiece. Battery 102 powers the circuits and transducers of the earpiece. Battery 102 can be a rechargeable or replaceable battery.

[0041] In at least one exemplary embodiment, electronic housing unit 100 is adjacent to sealing unit 108. Openings in electronic housing unit 100 receive ECM tube 110 and ECR tube 112 to respectively couple to ECM 106 and ECR 114. ECR tube 112 and ECM tube 110 acoustically couple signals to and from ear canal 124. For example, ECR outputs an acoustic signal through ECR tube 112 and into ear canal 124 where it is received by the tympanic membrane 126 of the user of the earpiece. Conversely, ECM 114 receives an acoustic signal present in ear canal 124 though ECM tube 110.

[0042] One function of ECM 106 is that of measuring the sound pressure level in the ear canal cavity 124 as a part of testing the hearing acuity of the user as well as confirming the integrity of the acoustic seal and the working condition of

the earpiece. In one arrangement, ASM 120 is used to monitor sound pressure at the entrance to the occluded or partially occluded ear canal 124. All transducers shown can receive or transmit audio signals to a processor 116 that undertakes audio signal processing and provides a transceiver for audio via the wired (wire 118) or a wireless communication path. Note also that the acoustic signals can be stored for later retrieval.

[0043] In at least one exemplary embodiment the earpiece can be constructed to actively monitor a sound pressure level both inside and outside an ear canal 124. In at least one exemplary embodiment monitored data can be used to enhance spatial and timbral sound quality while maintaining supervision to ensure safe sound reproduction levels. In at least one exemplary embodiment an earpiece can facilitate at least one of conducting listening tests, filtering sounds in the environment, monitoring warning sounds in the environment, presenting notification based on identified warning sounds, maintaining constant audio content to ambient sound levels, and filtering sound in accordance with a Personalized Hearing Level (PHL).

[0044] The earpiece can generate an Ear Canal Transfer Function (ECTF) to model the ear canal 124 using ECR 114 and ECM 106, as well as an Outer Ear Canal Transfer function (OETF) using ASM 120. For instance, the ECR 114 can deliver an impulse within the ear canal 124 and generate the ECTF via cross correlation of the impulse with the impulse response of the ear canal 124. The earpiece can also determine a sealing profile with the user's ear to compensate for any leakage. In at least one exemplary embodiment the earpiece can use

either the ASM 120 or the ECM 106 to monitor the sound pressure level, which can then be used in a Sound Pressure Level Dosimeter calculation, to estimate sound exposure and recovery times. This permits the earpiece to safely administer and monitor sound exposure to the ear.

[0045] Referring to **FIG. 2**, a block diagram of an earpiece in accordance with an exemplary embodiment is shown. A power supply 205 (e.g., USB power connection, hearing aid battery (ies)) powers components of the earpiece including microprocessor 206 (or processor 206, e.g., Texas Instruments TMS320C6713) and a data communication system 216 (e.g., RF or Bluetooth communication chip). As illustrated, the earpiece includes the processor 206 operatively coupled to data communication system 216, ASM 210, ECR 212, and ECM 208. Data communication system 216 may include one or more Analog to Digital Converters and Digital to Analog Converters (DAC). The processor 206 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) 202 and Read Only Memory 204. Other memory types such as Flash, non-volatile memory, SRAM, DRAM or other like technologies can be used for storage with processor 206. The processor 206 can also include a clock to record a time stamp.

[0046] In general, data communication system 216 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 216 is configured to communicate with

ECM 208, ASM 210, visual display 218, and user control interface 214 of the earpiece. As shown, user control interface 214 can be wired or wirelessly connected. In at least one exemplary embodiment, data communication system 216 is capable of communication to devices exterior to the earpiece such as the user's mobile phone, a second earpiece 222, and a portable media player 228. Portable media player 228 can be controlled by a manual user control 230.

[0047] The user's mobile phone includes a mobile phone communication system 224. A microprocessor 226 is operatively coupled to mobile phone communication system 224. As illustrated multiple devices can be wirelessly connected to one another such as an earpiece 220 worn by another person to the user's mobile phone. Similarly, the user's mobile phone can be connected to the data communication system 216 of earpiece 201 as well as the second earpiece 222. This connection would allow one or more people to listen and respond to a call on the user's mobile phone through their respective earpieces.

[0048] As illustrated, a data communication system 216 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 206 can provide functionality of

the VOX by way of software, such as program code, assembly language, or machine language.

[0049] The RAM 202 stores program instructions for execution on the processor 206 as well as captured audio processing data. For instance, memory RAM 202 and ROM 204 can be off-chip and external to the processor 206 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. In at least one exemplary embodiment, 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 is operatively connected with processor 206 to provide high speed data access. The storage memory can be non-volatile memory such as SRAM to store captured or compressed audio data.

[0050] Data communication system 216 includes an audio interface operatively coupled to the processor 206 and the VOX to receive audio content, for example from portable media player 228, cell phone, or any other communication device, and deliver the audio content to the processor 206. The processor 206 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 206 (or the VOX of data communication system 216) can lower a volume of the audio content responsive to detecting an event for transmitting the acute sound to the ear canal of the user. The processor 206 by way of the ECM 208 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 216.

[0051] The earpiece and data communication system 216 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 over-the-air to the earpiece. It should be noted also that next generation access technologies can also be used in exemplary embodiments.

[0052] Data communication system 216 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 201.

[0053] The power supply 205 utilizes 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 205 to improve sensory input via haptic vibration. As an example, the processor 206 can direct the motor to vibrate responsive to an action, such as a detection of a warning sound or an incoming voice call.

[0054] Microprocessor 206 is operatively connected with an EarSeal Inflation Management System 232 to control the degree to which the sealing unit 108 is inflated or deflated. In one exemplary embodiment, sealing unit 108 comprises an expandable element (e.g., inflatable balloon mechanism), whereby a cavity can be filled with air or a liquid to change the degree of acoustic isolation between the internal ear canal space 124 and the ambient environment. Alternately, a passive system for sealing ear canal 124 is used such as a flexible rubber or silicon sealing unit or a foam plug. In one exemplary embodiment, the passive system is a balloon mechanism that is filled with air or liquid. The balloon mechanism conforms to the shape and size of an ear canal and includes a restorative force module that applies a pressure to the balloon mechanism for sealing the ear canal cavity.

[0055] The earpiece is 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 are reused in different form factors for the master and slave devices.

[0056] Referring to **FIG. 3**, a flowchart illustrates a method for an acoustic sealing analysis system in accordance with an exemplary embodiment. In general, a first volume is acoustically isolated from a second volume. The test determines if the two volumes have sufficient acoustic isolation from one another. For example, cars are designed to have a quiet interior. Users of an automobile do not want to be subjected to the noise of the external environment. Thus, a car interior (first volume) is acoustically isolated from the external environment

outside of the automobile. Similarly, an earpiece having a sealing unit such as described in FIG. 1 will create a first volume (the ear canal) that is acoustically isolated from the ambient environment of the user (second volume). In either example, the acoustic sealing analysis system determines if there is sufficient acoustic isolation for the application. In the earpiece example, random or periodic testing of the seal may be beneficial because a new seal is formed in the ear canal when the device is put in the ear or it may shift over time depending on user activity.

[0057] A test signal is acquired in a step 304. For example, the test signal can be stored in memory or generated by a microprocessor. The test signal is provided to the acoustic transducer. The acoustic transducer or loudspeaker emits an acoustic signal corresponding to the test signal within the first volume. The acoustic field in the first volume is detected by an Ear Canal Microphone (ECM) in a step 308. The acoustic loading on both the ECR and ECM will change depending on the degree of acoustic sealing, thereby affecting the degree magnitude of the radiated ECR signal detected by the ECM. In general, as the degree of ear seal decreases, the effect of lumped air mass coupled to the ECR and ECM will decrease thereby increasing in Thevenin capacitance, which effectively reduces the transfer of low-frequency emitted sound from the ECR to the ECM.

[0058] In one exemplary embodiment, the test signal and the acoustic signal emitted by the loudspeaker into the first volume is a single frequency sine wave signal for testing leakage from one volume to another.

[0059] The degree of sealing between the first and second acoustic volumes is determined in a step 310. The cross-correlation between the emitted test signal and detected ECM signal is taken. In at least one exemplary embodiment, the test signal and the measured acoustic signal emitted by the loudspeaker are conditioned using a time delay and frequency dependent filter. The ear-seal is determined to be low (or "leaky") if the cross-correlated signals are below a predetermined value. In at least one exemplary embodiment, automatic adjustments to the sealing section are made (such as deflating and re-inflating the sealing balloon to reseal the sealing section including retesting). Alternately, an audible sound, vocal response, or visual response can be provided to let the user know that the earpiece is sealed correctly or incorrectly.

[0060] Referring to FIG. 1, the earpiece is used as an example to illustrate a test sequence as disclosed in **FIG. 3**. Sealing unit 108 occludes an opening of ear canal 124 creating a first volume (ear canal 124) and a second volume (the ambient environment). Sealing unit 108 has a first side exposed to ear canal 124 and a second side is exposed to or corresponds to the ambient environment external to the ear.

[0061] In at least one exemplary embodiment, processor 116 is configured to receive a test signal in memory 104. Processor 116 generates the test signal and provides the test signal to Ear Canal Receiver 114 (ECR 114). ECR 114 emits the test signal into Ear Canal Receiver Tube (ECR Tube 112). The test signal propagates through ECR tube 112 and into ear canal 124. Ear Canal Microphone tube 110 (ECM tube 110) is configured to receive an acoustic signal

incident on the first side of sealing unit 108. The test signal in ear canal 124 propagates through ECM tube 110 and is received by Ear Canal Microphone 106 (ECM 106). ECM 106 is configured to measure the test signal in ear canal 124 and provide the measured test signal to processor 116.

[0062] As shown, electronic housing unit 100 of earpiece 90 is adjacent to the second side of sealing unit 108. Electronic housing unit 100 is exposed to the ambient environment and for purposes of acoustic sealing analysis is considered the second side of sealing unit 108. Electronic housing unit 100 includes Ambient Sound Microphone 120 (ASM 120), which is configured to measure sounds in the ambient environment. Thus, ASM 120 receives and measures an ambient signal corresponding to a signal incident on the second side of sealing unit 108. ASM 120 provides the measured ambient signal to processor 116.

[0063] Ideally, sealing unit 108 is an acoustic barrier preventing the test signal or very little of the test signal from getting past sealing unit 108 and into the ambient environment. Conversely, sealing unit 108 if improperly sealed will pass some of the test signal. Processor 116 compares the test signal to the signal provided by ECM 106 corresponding to the acoustic signal in ear canal 124. In particular, processor 116 undertakes the cross-correlation between emitted test signal and the ECM signal.

[0064] Referring to **FIG. 4**, a flowchart of an exemplary method to determine the acoustic seal integrity of an earpiece in accordance with an exemplary embodiment is illustrated. In at least one embodiment of an acoustic sealing analysis system, the test signal is masked or used in a manner undetectable by

the user. This allows unobtrusive (periodic or non-periodic) testing to determine if a device is sealed correctly ensuring optimum system performance and more importantly user safety.

[0065] In at least one exemplary embodiment, an audio content is provided in a step 402. A step 404 stores the test signal in a test signal data buffer. For example, a single frequency sine wave is stored in the test signal data buffer. The output (or alternatively- input) of the test signal data buffer is optionally delayed by digital delay unit 406. The function of delay unit 406 is to time-align the emitted test signal with the ECM signal so the cross-correlation is sensitive to changes in ear seal.

[0066] A step 408 stores the test ECM signal in a test signal data buffer. The output (or alternatively- input) of the ECM signal buffer can be filtered with a low-pass filter 410. The low pass filter can be configured so that the pass-band covers the frequency of the test signal. In one exemplary configuration, the low-pass filter can be a cascaded bi-quad IIR type filter with the cut-off frequency equal to 10 Hz greater than the test signal frequency.

[0067] A step 412 cross-correlates the optionally delay test signal buffer with the low-pass filtered ECM signal buffer. An exemplary method for the cross-correlation algorithm is described in figure 5. The instantaneous cross-correlation (i.e. the cross-correlation at zero-lag) value from step 412 is compared with the cross-correlation threshold value 414 using comparator unit 416. If the instantaneous cross-correlation of the two signal buffers is less than the threshold value 414, then the seal test status is set to FAIL 418 (i.e. an ear-seal

leak is detected); otherwise, if the cross-correlation is suitably high, the seal test status is set to PASS 420.

[0068] Referring to **FIG. 5**, a flowchart of an exemplary embodiment to determine the instantaneous cross-correlation between a first and second audio signal. In at least one exemplary embodiment, the first audio signal is the test signal (i.e. a sine wave) and the second signal is the low-pass-filtered ECM signal.

[0069] The correlation between two signals x and y at time k using an exponential window is defined as:

[0070]
$$\rho(k) = \frac{S_{xy}(k)}{\sqrt{(S_{xx}(k)S_{yy}(k))}} \qquad (1)$$

[0071] Where

[0072]
$$S_{xx}(k) = \sum_{l=0}^{\infty} ce^{-\eta l} x_{k-l} y_{k-l} \qquad (2)$$
$$c = 1 - e^{-\eta}$$

[0073] And S_{xx} and S_{yy} are defined similarly as in (2) (replacing y with x for S_{xx} etc.).

[0074] It can be shown (see Aarts et al, 2001) that (1) can be approximated with the recursion:

[0075]
$$\hat{\rho}(k) = \hat{\rho}(k-1) + \gamma\left[\partial_k - \beta_k \hat{\rho}(k-1)\right]$$
$$\partial_k = 2x_k y_k \qquad (3)$$
$$\beta_k = \alpha x_k^2 \alpha^{-1} y_k^2$$

[0076] Where

[0077]
$$\alpha = \frac{y_{RMS}}{x_{RMS}}$$
$$\gamma = \frac{ce^{\eta}}{2x_{RMS}y_{RMS}} \qquad (4)$$

[0078] The cross-correlation estimate using the above recursion is modified for block-wise processing rather than the sample-by-sample basis. This modification replaces the sample values (i.e. x(k) and y(k)) with values for the *N*-length block mean, i.e.

[0079] $$x(k) = \frac{1}{N}\sum_{l=0}^{N-1} x(k-l)$$

[0080] Furthermore, the numerator for γ is replaced with a small constant and so is α (replacing α with a constant effectively un-normalizes the correlation estimate). It is found that the modified un-normalized block-wise cross-correlation accurately estimates the cross-correlation compared with using the standard cross-correlation for two signals.

[0081] The modified block-wise fast cross-correlation algorithm, as summarized in figure 5, comprises the following steps:

1. A first signal buffer 502 is accumulated. This signal buffer corresponds to the emitted test signal (i.e. the sine wave).
2. The RMS level of the first buffer is calculated 504 (x_{RMS}).
3. The mean level of the first buffer is calculated 506.
4. A second signal buffer 508 is accumulated. This signal buffer corresponds to the filtered ECM signal.
5. The RMS level of the second buffer is calculated 510 (y_{RMS}).

6. The mean level of the second buffer is calculated 512.
7. In step 514, γ (gamma) is approximated as:

$$\gamma = \frac{\Gamma}{2x_{RMS}y_{RMS}}$$

Where Γ is a small constant, e.g. 10E-3.

8. In step 516, ∂_k (delta) is calculated as twice the product of the first signal buffer mean and the second signal buffer mean.
9. In step 518, beta is calculated as the sum of the square of the mean value of the first buffer with the sum of the square of the mean value of the second buffer.
10. In step 520, the new temporary estimate of the correlation newRho_temp is calculated as: newRho_temp = (delta – beta*rho_old))
11. In step 522, the new estimate of the correlation newRho is updated by summing the previous estimate of the correlation with the product of gamma and the temporary estimate of the correlation newRho_temp.
12. In step 524, the "old" value of the correlation is set to the newest correlation estimate, ready for the next iteration of the update algorithm.
13. In step 526, the current correlation estimate between the emitted test signal and the received and filtered ECM signal is set as equal to the value of newRho.

[0082] Referring to **FIG. 6**, a flowchart of a method to determine when to emit the test signal. The test signal is emitted when the test can be performed unobtrusively to the user and also provides an accurate test. In at least one exemplary embodiment, a test event to determine if an earpiece is sealed correctly is initiated via a timing methodology. In a first timing scenario, the test event occurs after a delay of a first predetermined time period when the RMS of the Audio Content (AC) is less than a RMS threshold. In a second timing scenario, the delay of the first predetermined time period is allowed to lapse without the test event occurring when the RMS of the audio content is greater than the RMS threshold. A second predetermined time period is started where the test event occurs when the RMS of the audio content is less than RMS threshold. The test event is then initiated when the second predetermined time period is exceeded independent of the RMS of the audio content.

[0083] A test sequence is initiated in a step 602. The previous seal test event resets the first digital timer in a step 604. A time delay is generated by the loop comprising steps 606 and 608. The first digital timer is time incremented in the step 606. After each added time increment, the first digital timer is compared against a digital_timer_threshold1. The first digital timer is time incremented (after the time has advanced another increment) after the comparison in the step 606 if the first digital timer is less than the digital_timer_threshold1.

[0084] A second digital timer is reset in a step 610 when the first digital timer is greater than the digital_timer_threshold1. The second digital timer is time incremented in a step 612. Audio content (AC) from a signal buffer is retrieved in

a step 614. The audio content can be filtered through a low pass filter in an optional step 616. The RMS of the audio content is calculated in a step 618. The calculated RMS of the audio content is compared against an RMS_threshold 622 in a step 620. The second digital timer is compared against a digital_timer_threshold2 in a step 624 if the RMS of the audio content is greater than the RMS_threshold. The second digital timer is time incremented (after the time has advanced another increment) when the second digital timer is less than digital_timer_threshold2 in the step of 624.

[0085] The audio content signal is mixed with the test signal when the RMS of the audio content is less than the RMS_threshold in a step 626. Also, the audio content signal is mixed with the test signal when the second digital timer is greater than digital_timer_threshold2 in the step 626. The modified audio signal (having the test signal mixed in) is emitted by the ECR in a step 628 for testing the sealing section of the earpiece. The first digital timer is then reset in the step 604 to begin a timing sequence for another sealing section test.

[0086] **FIG. 7** is a graph illustrating different seal measurements in accordance with the present invention. The estimated un-normalized cross-correlation between the ECM signal and the test signal (i.e. sine wave) is shown for different sine wave frequencies from 30-80 Hz. Three different curves are provided corresponding to a good fit (i.e. a tight optimal seal providing approximately 20-30 dB of acoustic attenuation), mid or partial seal (i.e. an ear-seal that could be characterized as "half in" providing approximately 10-15 dB of acoustic attenuation), and a poor seal (i.e. an ear-seal providing less than 10 dB of

acoustic attenuation). At lower test frequencies, the change in correlation is more pronounced as the degree of ear seal fitting is changed from "good" to "mid" and "poor". From the data, the threshold used to determine whether the ear seal can be characterized as "good" is approximately -20 dB, (i.e. 0.85 of FIG. 10 which corresponds to the value for XCorr_threshold 414 in FIG. 4).

[0087]

In at least one exemplary embodiment, the test signal for testing a seal of a sealing section is less than 200 hertz. The frequency of the emitted test signal is chosen to satisfy the requirements of being able to reveal small degradations in ear seal quality. It is also beneficial if the selected test signal frequency can be acoustically masked by reproduced audio to minimize detection of the test by an earpiece user. Both of these criteria are met using a test signal frequency below 200 Hz. The sensitivity is highest from the measured data at frequencies below 50 Hz. Conversely, as the test signal frequency increases the cross-correlation difference between a "good" and "bad" acoustic seal decreases. For example, with a 40 Hz test tone, the cross-correlation for a "good" ear seal is -8 dB, and for a bad ear seal it is -68 dB (i.e. a 60 dB difference). At a test signal frequency of 80 Hz, the cross-correlation for a "good" ear seal is -8 dB and for a bad ear seal it is -38 dB (i.e. a 30 dB difference). Thus, above 200 Hz the cross-correlation difference between a "good" and "bad" acoustic seal is further reduced thereby reducing the sensitivity of the test.

[0088] Using the cross-correlation rather than a level differencing approach improves the accuracy and minimizes errors which occur due to user non-speech

body noise, such as teeth chatter; sneezes, coughs, etcetera. Furthermore, such non-speech user generated noise would generate a larger sound level in the ear canal than on the outside of the same ear canal producing inaccurate results.

[0089] **FIG. 8** is a flowchart to adjust the degree of acoustic sealing of an Inflation Management System (IMS) in accordance with an exemplary embodiment. The IMS is adjusted depending on the degree of acoustic sealing provided by an earpiece is shown. The acoustic sealing is measured as disclosed in FIG. 7 and the result provided in a step 804 to determine the cross-correlation (XCorr) between a test signal and corresponding ECM signal. In general, the higher the cross-correlation, the higher the degree of acoustic sealing. An exemplary graph showing the relationship between XCorr and acoustic sealing is given in **FIG. 10.** The degree of acoustic sealing is determined from known XCorr using a look-up (or "hash") table or using a formula (e.g. of a polynomial form) that maps the acoustic sealing to the known XCorr value. The ambient sound level is measured in a step 806. The ambient sound level corresponds to the noise level in proximity to the user. In general, a higher degree of attenuation is desired when the ambient sound levels are high. Conversely, at low ambient sound levels the attenuation level of the IMS may be less of an issue and comfort more of a factor. The IMS is adjusted in a step 808 to meet the attenuation needs. In general, inflating the IMS increases attenuation while deflating the IMS decreases attenuation.

[0090] Referring to **FIG. 9**, is a more detailed flowchart to adjust the degree of acoustic sealing of an Inflation Management System (IMS). In general, the

attenuation increases when the pressure in the IMS is raised thereby allowing a degree of control to make adjustments. For example, an adjustment is made to increase attenuation when the background noise level rises or a seal check produces a failed result. Adjustments are made until the seal check passes. The pressure level adjustments of the IMS will fall within a comfort range of a user (e.g., between 0.1 bar and 0.3 bar gauge pressure). Typically, the pressure level is set at a minimum level to achieve a predetermined attenuation level.

[0091] The degree of acoustic sealing is determined from cross-correlation between the ECM signal and the test signal generating. The XCorr value is provided in a step 906. The attenuation provided by the IMS is calculated (equation) or looked up (table) from data such as that shown in FIG. 10. In one exemplary embodiment, the desired attenuation value is dependant on the ambient sound level of the user. In another exemplary embodiment, the desired attenuation value is dependant on the ear-canal sound level of the user. In yet another exemplary embodiment, the desired attenuation value is dependant on the level of audio content (e.g. speech or music audio) reproduced with the earphone device. In all of the above examples, the desired attenuation value is determined by one or more of the embodiments in a step 907.

[0092] The difference between the degree of acoustic sealing determined in step 906 and the desired attenuation value determined in step 907 is calculated in step 908. The difference value in step 908 is used to determine the change in pressure of the IMS necessary to minimize the difference value in a step 910. In at least one exemplary embodiment, the difference value of the attenuation is

converted into a corresponding pressure value change (e.g. in milli-Bars) using a similar look-up table or equation method as described previously. The pressure change in the IMS is then affected with step 912 to meet the desired attenuation level. For example if the desired attenuation is a decrease of 10dB in sound across the earpiece in the ear canal, then a pressure of a variable volume inflatable system can have a gauge pressure of about 0.15 bar. If the desired attenuation is a decrease of 20dB across the earpiece in the ear canal then the gauge pressure can be increased to about 0.25 bar. Where an increased pressure is associated with an increase in attenuation. An experimental table for each earpiece can be generated in a standard devised experimental setup (e.g. impedance tunnel) and referred to when changes are needed.

[0093] Referring to **FIG. 11**, a flowchart of an exemplary method to determine a test signal fundamental is illustrated. In at least one embodiment of an acoustic sealing analysis system, the test signal is masked or used in a manner undetectable by the user or made pleasant such that the user is unaware that the test signal is being played. This allows unobtrusive (periodic or non-periodic) testing to determine if a device is sealed correctly ensuring optimum system performance and more importantly user safety.

[0094] In at least one exemplary embodiment, an audio content 1102 is provided. A step 1104 stores audio content 1102 in a data buffer. In this example, audio content 1102 is music played from a media player and received via a wired or wireless connection to at least one earpiece in the user's ear. An

alternate example would be that audio content 1102 is a speech audio signal from a portable telephone device or the like.

[0095] A step 1106 determines if the buffer of audio content 1102 comprises a strong tonal signal component. Mixing the test signal having a similar fundamental frequency as audio content 1102 will mask the test signal when played to the user. Thus, the test signal is musically in harmony with the reproduced music and results in very little perceptual degradation in sound quality.

[0096] A step 1108 determines whether to update or generate the first fundamental tone for the test signal. The test signal is not updated or generated if buffered audio content 402 does contain a strong tonal signal component. A return to step 1104 fills the buffer with the next audio content 402 for analysis.

[0097] A step 1110 analyzes the buffer of data of audio content 1102 when it has been determined that it contains a strong tonal signal component. Step 1110 determines the fundamental frequency of the tonal signal. The fundamental tone, often referred to as the fundamental and abbreviate f_o, is the lowest frequency in a harmonic series. The fundamental frequency (also called a natural frequency) of a periodic signal is the inverse of the pitch period length. The pitch period is the smallest repeating unit of a signal. The fundamental frequency of the tonal signal can be calculated using an autocorrelation analysis.

[0098] In one exemplary embodiment, a mathematical operation 1114 is performed where the frequency component of the test signal is limited to a frequency range below a lower minimum and upper maximum frequency range.

Fund_ratio is calculated, which is defined as a ratio of the determined fundamental frequency (F_fund) of the tonal signal from step 1110 to an upper threshold value F_fund_threshold 1112, which in one exemplary embodiment, is a fixed constant equal to approximately 100 Hz. In general, F_fund_threshold 1112 is chosen to be a low frequency value which is above the lowest (or -3 dB) frequency that a transducer can reproduce, but below a predetermined frequency. In a comparison step 1116, if the estimated F-fund is higher than the F_fund_threshold 1112 (ratio >1), then F_fund is reduced by an integer multiple to be below F_fund_threshold corresponding to the mathematical operation of step 1118. Otherwise, the test signal fundamental is equal to F_fund as shown in step 420. Although not shown, the calculated test signal fundamental is compared and determined to be greater than a predetermined threshold.

[0099] Referring to **FIG. 1**, in at least one exemplary embodiment, processor 116 is configured to receive or generate audio content. As mentioned previously, the audio content can from external devices such as a portable phone or media player. Memory 104 can be used as a buffer for the audio content. Processor 116 is configured to receive the buffer of audio content from memory 104. The steps and calculations of the block diagram of **FIG. 4** are then performed by processor 116. The result being one of the identification of a strong tonal signal component in the buffer of audio content and the test signal fundamental or loading the buffer with new audio content and starting the process again.

[00100] Referring to **FIG. 12**, a flowchart of an exemplary embodiment to determine tonal presence in audio content is shown. In particular, the exemplary

embodiment relates to step 1106 of **FIG. 11** that analyzes audio content stored in a buffer. A step 1204 gets the audio content stored in an audio signal buffer hereinafter called the audio signal. A filter step 1206 filters the audio signal to a frequency range of interest that relates to a sealing test frequency. For example, a band pass filter in the range of 20 Hz to 500 Hz could be used to filter the audio signal where the test signal is in the lower audio frequency range. An auto-correlation step 1208 analyzes the audio signal where a strong tonal signal component is represented by peaks in the analysis results. A step 1210 generates Absolute(Acorr) which is a number representing the absolute magnitude of the peaks from the analysis. For example, Absolute(Acorr) can be the square of the results from the auto-correlation.

[00101] A crest_factor_Acorr 1218 is generated from the results by calculating an RMS value 1214 (or time-averaged peak value) and peak value 1216 (or time averaged peak value). In at least one exemplary embodiment, the crest_factor_Acorr 1218 is the ratio of the peak value to the RMS value of an absolute auto-correlation sequence of the audio signal.

[00102] A comparison step 1222 is then performed. A strong tonal presence is identified when crest_factor_Acorr 1218 is greater than a threshold Crest_factor_Acorr_threshold 1220. Identification of the strong tonal presence indicates the audio signal would facilitate masking of the test signal to determine sealing of the device. The audio signal is not used in conjunction with the test signal if crest_factor_Acorr 1218 is less than Crest_factor_Acorr_threshold 1220.

The process would begin again loading a next sequence of the audio signal into the buffer for review.

[00103] Referring to **FIG. 1**, as mentioned previously, audio content is stored in a buffer, for example memory 104. The audio content in the buffer is provided to processor 116. In at least one exemplary embodiment, processor 116, runs the analysis as described in the block diagram of **FIG. 12** thereby determining if a strong tonal presence is found in the audio content in the buffer. New audio content is loaded into the buffer (memory 104) if a strong tonal presence is not found beginning the procedure again.

[00104] Referring to **FIG. 13**, a flowchart of a method to determine when to emit the test signal. The test signal is emitted when the test can be performed unobtrusively to the user and also provide an accurate test. In a step 1304, an audio signal is retrieved from a buffer. In at least one exemplary embodiment, the audio signal is received from an ECM or an ASM. The audio signal is measured to determine when the sound level is low in the ear canal, the ambient environment, or both. In general, the test signal is emitted when the sound level is low.

[00105] A filter step 1306 band pass filters the audio signal. In one exemplary embodiment, filter step 1306 filters the audio signal from 50 Hz to 150 Hz which corresponds to a frequency range of the test signal. In a step 1308, the RMS of the audio signal is calculated. The audio signal is analyzed to detect when the energy within an audio frequency range is below a threshold RMS_threshold 1310. The RMS of the audio signal is the signal level in the volume being

measured. A comparison step 1312 compares the measured RMS level of the filtered audio signal against RMS_threshold 1310. In a step 1314, a test signal is emitted when the measured RMS value is less than RMS_threshold 1310. No test signal is emitted when the RMS of the audio signal is greater than RMS_threshold 1310.

[00106] Referring to **FIG. 14**, a flowchart of an exemplary method to determine acoustic seal integrity is illustrated. For example, an earpiece seal integrity corresponds to a full or partial acoustic barrier between a first volume (ear canal) and a second volume (ambient environment). In one exemplary embodiment, the degree of acoustic seal integrity is expressed as either a PASS or FAIL status, where FAIL indicates that the acoustic seal is compromised relative to a normal operating acoustic seal. For example, an earpiece that has performed the seal test and determined that the sealing unit is not sealed correctly in the ear canal of the user can provide a signal or message indicating the problem. The user can then remove, reinsert, and retest the earpiece to ensure that the seal is within normal operating specifications.

[00107] An acoustic test signal is provided in a first volume. In a step 1402 a transducer measures the acoustic test signal and stores it in a signal buffer. In a step 1404, a second transducer in a second volume isolated from the first volume by an acoustic barrier measures a second acoustic signal in the second volume. A portion of the acoustic test signal passes the acoustic barrier into the second volume. The amount of the acoustic test signal passing the acoustic barrier is a measure of the seal provided by the acoustic barrier.

[00108] In a filter step 1406, the measured acoustic test signal in the first volume is filtered in a frequency range corresponding to the acoustic test signal to remove signals that are not part of the test. The measured signal from the first volume is heretofore called the first volume signal. Similarly, in a step 1408, the measured signal in the second volume is filtered in a frequency range corresponding to the acoustic test signal to remove signals not related to the test (outside the frequency range) in the second volume. The measured signal from the second volume is heretofore called the second volume signal.

[00109] A correlation, cross-correlation, or coherence analysis is performed on the first volume signal and the second volume signal. The correlation, cross-correlation, or coherence analysis is a measure of the similarity of the signals in the first and second volumes. In particular, the non-difference analysis measures the acoustic test signal leaking past the acoustic barrier by identifying the portion of the second volume signal that is similar to the acoustic test signal in the first volume.

[00110] In at least one exemplary embodiment, a correlation step 1412 is performed comprising a cross-correlation of the first volume signal and the second volume signal. In a step 1414, the peak of the cross-correlation is identified. The peak of the cross-correlation is Absolute(XCorr). In a mathematical step 1418, the Lag-time of Peak 1420 and the Magnitude of Peak 1422 is calculated. The Lag-time of Peak 1420 is a measure of the time delay between receiving the signals in the first and second volumes. In particular, the first volume signal should be received before the second volume signal. The

Magnitude of Peak 1422 corresponds to the similarity between the signals in the first and second volumes. Thus, a larger number for Magnitude of Peak relates to more leakage of the acoustic test signal getting past the acoustic barrier.

[00111] Two comparisons are performed that determine if the acoustic barrier is sealed correctly based on the measured and calculated data from the first and second volumes. In a comparison step 1426, the measured Lag-time of Peak is compared against Target Lag Limits 1424. The measured lag-time should fall within the predetermined range (Target Lag Limits 1424) for the seal test to be valid. If the Lag-time of Peak is within the appropriate range than a logic 1 is provided to AND function 1432, otherwise a logic 0 is provided. In a second comparison step 1428, the Magnitude of Peak is compared against a Peak_threshold. If the Magnitude of Peak is greater than the Peak_threshold a logic 1 is provided to AND function 1432. This indicates that a significant portion of the acoustic test signal is present in the second volume measurement, otherwise a logic 0 is provided. A FAIL output corresponds to a logic 1 at the output of AND function 1432. The FAIL occurs when the Lag-time of Peak is within the predetermined range and the Magnitude of Peak is greater than the Peak_threshold indicating that the acoustic barrier is sealed improperly. All other conditions indicate a PASS and the acoustic barrier is sealed correctly.

[00112] In at least one exemplary embodiment and referring briefly to **FIG. 1**, an earpiece 90 is tested to determine if sealing unit 106 is sealed correctly to the ear canal of the user. Sealing unit 108 creates a first volume in ear canal 124 and a second volume outside the ear canal in the ambient environment. A masking

approach is used to perform seal testing unobtrusively to the user. The user is listening to music or speech (audio content) provided to ear canal 124 from ECR 124.

[00113] The music or speech is buffered in memory 104 or memory in processor 116. Processor 116 analyzes the audio content in the buffer to identify a strong tonal content. A test signal can be created once audio content with strong tonal content is found. The test signal will have at least one fundamental pitch corresponding to the strong tonal content and optionally further harmonics. Processor 116 also analyzes the measured signals from ECM 106 and ASM 120 to determine when to emit the test signal. Processor 116 monitors and compares the sound level in the ambient environment and ear canal 124. Processor 116 will provide the generated test signal to ECR 114 during an optimum time for test accuracy such as when the ambient sound level is low, ear canal sound level is low, or both. Also, processor 116 will not output the test signal if there is audio content similar to the test signal in the ear canal or ambient environment.

[00114] Processor 116 monitors the test conditions and then provides the test signal to ECR 114 when an accurate sealing test can be performed. ECR 114 outputs an acoustic test signal which may or may not have other audio content. ECM 106 and ASM 120 respectively measure acoustic signals in ear canal 124 and the ambient environment. Processor 116 is operatively coupled to ECM 106 and ASM 120. The measured signals are buffered in memory.

[00115] In an exemplary embodiment, a cross-correlation is used to measure the similarity between the signals in ear canal 124 and the ambient environment.

Processor 116 performs the cross-correlation calculations using the measured acoustic signals from ECM 106 and ASM 120. In particular, the cross-correlation is used to identify and compare the acoustic test signal present in the two volumes separated by the acoustic barrier. A cross-correlation between ASM and ECM signals is defined according to the following equation (1):

$$XCorr(n,l) = \sum_{n=0}^{N} ASM(n)ECM(n-l),$$

Where:

$$l = 0,1,2,...N \qquad (1)$$

[00116] Where *ASM(n)* is the n^{th} sample of the ASM signal, and ECM(*n*-1) is the $(n-1)^{th}$ sample of the ECM signal. A peak of the absolute cross-correlation is estimated using a peak-picking function and also the lag time at which this peak occurs (i.e. the index l at which this occurs). Thus, the Lag-time of Peak and the Magnitude of Peak are known and respectively compared against a Target Lag Limit range and a Peak Threshold. The user of earpiece 90 is notified or warned that seal unit 108 is improperly sealed by processor 116 if the measured Lag-time of Peak is with the Target Lag Limit range and the Magnitude of Peak is greater than the Peak Threshold.

[00117] Like Correlation and Cross-Correlation, a coherence function is also a measure of similarity between two signals. Coherence is another non-difference comparison approach that can be used for detecting acoustic seal integrity. Coherence is defined as:

$$\gamma^2_{xy} = \frac{|G_{xy}(f)|^2}{G_{xx}(f)G_{yy}(f)} \quad (2)$$

[00118] Where G_{xy} is the cross-spectrum of two signals (e.g. the ASM and ECM signals), and can be calculated by first computing the cross-correlation in equation (1), applying a window function, for example a Hanning window, and transforming to the frequency domain, for example via an FFT. G_{xx} or G_{yy} is the auto-power spectrum of either the ASM or ECM signals, and can be calculated by first computing the auto-correlation (using equation 1, but where the two input signals are both from either the ASM or ECM and transforming to the frequency domain. The coherence function gives a frequency-dependant vector between 0 and 1, where a high coherence at a particular frequency indicates a high degree of coherence at this frequency, and can therefore be used to analyze test signal frequencies in the ASM and ECM signals whereby a high coherence indicates the presence of the test signal in the ambient environment (indicating leakage past the acoustic barrier.

[00119] Other approaches such as frequency spectrum analysis and RMS levels can also be used to determine if earpiece 90 is sealed correctly. Using a non-difference comparison approach such as coherence or cross-correlation between the ASM and ECM signals to determine sealing is more reliable than taking the level difference of the ASM and ECM signals. Using the cross-correlation rather than a level differencing approach improves the accuracy and minimizes errors which may occur due to user non-speech body noise, such as teeth chatter; sneezes, coughs, etcetera. Furthermore, such non-speech user generated noise

would generate a larger sound level in the ear canal than on the outside of the same ear canal producing inaccurate results.

[00120] Figures 15A and B illustrates a method of varying the seal of an inflation system in accordance with at least one exemplary embodiment. In the non-limiting example, when a seal is essentially detected as being low, for example the calculated sound isolation of the system is 3 dB or less, a signal is sent to a seal varying device (e.g., 1500) to vary the seal, in this case increase (i.e. increase the sound isolation of the system) the seal value. The signal can be instructions to send a current over a period of time to an actuator, which can decrease the overall volume of the system (hence increasing the pressure and effectively the sealing). For example a slider actuator such as the P-653 PILine® can be used. Which has the dimensions of 15mm by 11mm by 8mm, which includes an attached electronics control board, and has the mass of 1 gram. General operation uses 5V and about 100 mamps with a typical speed of 50 to 90 mm/sec. Note that the max force of about 0.15N but such systems can be tailored to enable pumping beyond atmospheric pressure (e.g., can increase the max force). The non limiting example illustrated in Figures 15A and 15B shows a slider actuator 1500, with a moving slide 1510, having attached a pumping arm 1560, with a hole covering bump 1520. Upon receipt of a signal 1505 the actuator can move 1570 such that the bump covers the hole 1550 in a bellows 1530 pump. The actuation compresses the miniature bellows pushing 1560 gas through the one-way valve 1540, upon the back stroke the bump uncovers the hole and air rushes back into he bellows for the next pump. For

example if the stroke length is 2mm and the pump arm contact area is about 9mm^2 then each stroke moves 18mm^3 of volume. If an inflation system 1570 needs to be inflated more (e.g., more gas to increase sealing) then each stroke can provide an additional volume of gas of 18mm^3 into the system increasing the inflation system 1580. If the inflation system is initially empty (e.g., needs 1000mm^3 of gas volume to inflate) then about 56 strokes would be needed for inflation, which is about 110mm one direction stroke length or about 2 seconds at P-653 PILine speeds. The number of oscillations and stroke length can be determined according to the signal sent 1505, which can be specifically tailored depending upon the electronics controlling the actuators. Note that PI-653 is an example only. Other actuation systems can be used and controlled by signal 1505.

[00121] Figure 16 illustrates a block diagram of controlled sealing in response to a seal fail signal and/or a request for increased seal attenuation. For example a command signal 1600 is received (e.g., a seal fail signal in which a default attenuation value is attached for example 15dB, or a signal requesting an additional amount of attenuation) by a processor. The command signal specifies and additional amount of attenuation or that the seal has failed. An attenuation needed N is identified 1610. For example if the current attenuation is 5dB loss at f=500Hz, at a pressure of 0.1 bar, and a command signal is received requesting a 10dB loss at 500Hz, then an experimental table is queried to find the pressure needed P which is then subtracted from the current pressure to obtain an increase in pressure DP needed. The increase in pressure is converted into a

volume of gas increase needed (e.g., again referring to experimental tables based upon the inflation system volume). The volume of gas increase needed can then be directly linked with the number of cycles of an actuator pump M, 1620. The number of requested cycles M can then be sent 1630 to the actuator control circuit to pump the designated number of cycles. The system can then retest the attenuation and if refinements are needed the process can start again.

[00122] 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., 90 degrees) should be interpreted to be "about" the value of the stated number (e.g., about 90 degrees).

[00123] 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.

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/555,864

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	82		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	270		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	110		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	53 minus 20 =	33	x$26	858	OR	x$52	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	6 minus 3 =	* 3	x$110	330		x$220	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			195			390	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	1650		TOTAL	

APPLICATION AS AMENDED – PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
						TOTAL ADD'T FEE		OR	TOTAL ADD'T FEE	

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