UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

BOSE CORPORATION,
Petitioner,

v.

KOSS CORPORATION,
Patent Owner.

Case No. TBD
Patent No. 10,206,025

DECLARATION OF JOHN G. CASALI, Ph.D., CPE

Bose Exhibit 1005
Bose v. Koss

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I, John G. Casali, declare:

1. I have been retained by Wolf, Greenfield & Sacks, P.C., counsel for Petitioner Bose Corporation, to submit this declaration in connection with Bose's petition for *inter partes* review of claims 1-56 (the "challenged claims") of U.S. Patent No. 10,206,025 (Ex. 1001, "the '025 patent"). I am being compensated for my time at my standard rate of $600 per hour, plus actual expenses. My compensation is not dependent in any way upon the outcome of the *inter partes* review of the '025 patent.

I. BACKGROUND AND QUALIFICATIONS

2. I am the John Grado Chaired Professor of Industrial and Systems Engineering at Virginia Polytechnic Institute and State University in Blacksburg, Virginia ("Virginia Tech"). I am also the founder and Director of the Auditory Systems Laboratory at Virginia Tech.[1] I have been an engineering professor at Virginia Tech since 1982, and founded the Auditory Systems Laboratory in 1983.

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[1] My work at Virginia Tech as a Chaired Professor and former Department Head involves the procurement of research and foundation funding support from a variety of outside sources, including U.S. military, U.S. government, and corporate sources. Over the years, I have been responsible for procuring more than $14 million in total funding support at Virginia Tech, approximately $6M of which is

3. I am a Founding Partner and Chief Technology Officer of Hearing, Ergonomics & Acoustics Resources LLC, d/b/a "H.E.A.R. LLC," a small consulting company chartered in Virginia in 2015 that specializes in hearing-related, ergonomics, and acoustical consulting as applied to product and systems design, product testing and evaluation, intellectual property assistance, forensics and litigation support, and military research and development.

4. I attended Virginia Tech as an undergraduate and graduate student, obtaining a B.S. in Psychology in 1977, a Master of Science in 1979, and a Ph.D. in Industrial Engineering with concentration in Human Factors Engineering in 1982.

5. I have been certified since 1993 by the Board of Professional Ergonomists as a Certified Professional Ergonomist (CPE), registration #222.

A. Research Contracts and Grants at Virginia Tech and at H.E.A.R. LLC

6. In 1983, I founded the Auditory Systems Laboratory at Virginia Tech, and since that time, have served as its sole Director. My work at Virginia Tech as a Chaired Professor and former Department Head involves the procurement of

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directly related to the support of research on applied acoustics and ergonomics issues. None of this funding is related in any way to this case nor the outcome of it.

research and foundation funding support from a variety of outside sources, including U.S. military, U.S. government, and corporate sources.

7. At Virginia Tech, I have served as Principal Investigator on over 100 sponsored research contracts and grants, with over half of these being conducted for various U.S. military branches or military equipment suppliers. The largest single category of these projects involves hearing protection and headphone research, development and/or testing.[2] My total research contract and grant funding at Virginia Tech exceeds $6 million, with another $8 million in private foundation support of various types.[3]

8. The Auditory Systems Laboratory physical facility consists of anechoic, reverberant, and hemi-anechoic sound chambers, as well as an outdoor acoustic test range. At the Auditory Systems Laboratory, we apply principles and methods of human factors engineering, ergonomics, and acoustics to solve research problems concerning human hearing conservation, auditory information display, auditory situation awareness, auditory warnings and alarms, communications systems, and auditory product design. The Laboratory is equipped to provide

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[2] Some of this work is military sensitive, subject to United States ITAR and Export Controls, and/or is proprietary.

[3] None of this funding is related in any way to this matter or its outcome.

versatile research and testing services for a wide variety of acoustics, hearing protection and human factors-related applications, including attenuation testing and noise reduction rating (NRR) testing for hearing protection devices per American National Standards Institute (ANSI) and United States Environmental Protection Agency (EPA) requirements. The Laboratory is further known for its seminal work over the past 15 years in the testing and measurement of hearing protection and headphone effects on auditory situation awareness, and for developing protocols and training systems for improving a soldier's (or others') abilities to identify and localize sounds via regimented training in an indoor environment, and the transfer of that training to the field environment.

9. Clients of the Auditory Systems Laboratory have included the U.S. Army Research Lab, U.S. Army Aeromedical Research Lab, U.S. Naval Submarine Medical Research Lab, Office of Naval Research, U.S. Air Force, NASA, Federal Highway Administration, U.S. Bureau of Mines, National Institute for Occupational Safety and Health (NIOSH), National Institutes of Health, Virginia Center for Innovative Technologies, United Parcel Service, Lockheed-Martin, Battelle, Inc., ALCOA, Bose Corporation, Cabot Safety Corporation, Aearo Corporation, Peltor AB (Sweden), ITT, Inc., Etymotic Research, Inc., Henry Dreyfuss Associates, Noise Cancellation Technologies, Sound Innovations Corporation, Korea Research Fund, Carilion Biomedical Institute, Adaptive

Technologies, Inc., Shure Corporation, Tetra Corporation, and Toyota Motor Corporation, among others.

10. At H.E.A.R LLC, I have been largely responsible for procuring approximately $1.2 million in funding on contracts from the U.S. Office of Naval Research for hearing protection and auditory situation awareness research, as well as additional smaller funding amounts from various companies for hearing protection and earphone research and development.

11. Over the course of my 38-year university research and consulting career, my core areas of focus have included acoustics and human hearing, auditory situational awareness, acoustical testing and noise measurement, and hearing-related product design, as well as signal detection, localization, and speech communications in noise. I also have worked in the areas of human mental workload, driver performance, aircraft pilot performance and driving/flight simulator design and application.

12. The most extensive core area of my work has involved the design and testing of hearing protection devices ("HPDs"), headsets, earphones, headphones, and hearing-protective Tactical Communications and Protective Systems ("TCAPS"). This line of work has included research inquiry into measurement standards, test protocols, variables of influence on attenuation and comfort achieved, design features and alternatives, and the testing of attenuation, auditory

situational awareness, comfort and usability, and speech intelligibility. As part of this work, my laboratory has conducted hundreds of NRR tests on all types of hearing protectors, as well as Microphone-in-Real-Ear (MIRE) and acoustical test fixture (ATF) tests to determine attenuation and other performance aspects provided by specialized products, such as Active Noise Reduction (ANR) and electronic sound transmission devices. In many instances of my research work with military and civilian headsets, HPDs, and headphones, since the mid-1980's I have emphasized the importance of user acceptance of devices, ease-of-fit, stability in the ear, comfort, and various design features and alternatives, in addition to the more objective performance measures of attenuation and situation awareness. Example publications over the years on these usability and performance subjects include Casali, J. G., Ahroon, W. A., and Lancaster, J. (2009) A field investigation of hearing protection and hearing enhancement in one device: For soldiers whose ears and lives depend upon it. *Noise and Health Journal, 11*(42), 69-90; Casali, J. G. (1992) Comfort: the "other" criterion for hearing protector design and selection. Proceedings of the 17th Annual National Hearing Conservation Association Conference, Cincinnati, Ohio, April 1-4, 47-53. (Also in *Spectrum, 9*, Supplement 1, Winter 1992, 26); Park, M. Y. and Casali, J. G. (1991) An empirical study of comfort afforded by various hearing protection devices: laboratory versus field results. *Applied Acoustics, 34*, 151-179; Casali, J. G., Lam, S. T., and Epps, B. W.

(1987) Rating and ranking methods for hearing protector wearability. *Sound and Vibration, 21*(12), 10-18. All of my publications are listed on my resume, but one particular example which involves electronic ear-mounted product (hearing protector and headphone) design features is: Casali, J. G. (2010) Powered electronic augmentations in hearing protection technology circa 2010 including Active Noise Reduction, electronically-modulated sound transmission, and tactical communications devices: Review of design, testing, and research. *International Journal of Acoustics and Vibration, 15*(4), 168-186.

13. Through my work at the Auditory Systems Laboratory and more generally throughout my career, I am deeply familiar with, and have applied extensively, the EPA regulations on hearing protector testing and labeling (40 CFR § 211)[4] and ANSI standards governing hearing protector testing. I am also familiar with, and have applied, certain human factors and acoustical aspects of U.S. military standards.

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[4] U.S. Environmental Protection Agency (EPA) (1979), Noise Labeling Requirements for Hearing Protectors," 40 CFR § 211, Code of Federal Regulations, *Federal Register*, Washington, DC. (Hereafter, 40 CFR § 211.)

B. Research and Practice Focus Areas

14. I have had significant involvement with military and civilian device testing and evaluation efforts, with particular emphasis on hearing protection and headphone effectiveness, and its impact on an individual's hearing and communications abilities, which affects situational awareness. The U.S. military has contracted with my Auditory System Laboratory to conduct HPD testing and engage in analysis of HPD effectiveness for tactical situations, situation awareness, or other mission-specific situations.

15. I am currently the Principal Investigator on a $372,000 contract for the Office of Naval Research, to develop a portable auditory localization test and training system to determine effects of hearing protectors on situation awareness and to train soldiers to improve these abilities in an indoor barracks or office environment.

16. In November 2015, I completed as Principal Investigator at Virginia Tech, a $470,000 contract for the Department of Defense's Hearing Center of Excellence, to develop a comprehensive, objective test battery for measurement of the effects of HPDs and TCAPS on military personnel's auditory situational awareness. This work included development of test protocols and metrics for <u>d</u>etection, <u>r</u>ecognition and <u>i</u>dentification, <u>l</u>ocalization, and <u>c</u>ommunications (known as 'DRILCOM') while wearing HPDs and TCAPS.

17. From 2010 to 2013, at the request of the Naval Submarine Medical Research Lab (NSMRL) in Groton, CT, I served on an Interagency Personnel Agreement (paid salary) with my regular employer (Virginia Tech), to complete a research contract with NSMRL to develop and install a calibrated hearing protection device attenuation-testing facility on the Navy base in Groton.

C. Professional Service, Recognitions and Accomplishments

18. I am a Fellow of the Human Factors and Ergonomics Society, and have won several awards from that Society, as follows. In 2017, I received the *Lauer Safety Award* for outstanding contributions in the application of human factors engineering to safety issues. I also received the *Paul M. Fitts Education Award* in 1997 and the *Jack A. Kraft Innovator Award* in 1991. I am also a Fellow of the Institute of Industrial & Systems Engineers, and received the *Dr. David. F. Baker Distinguished Research Award* in 1996, and the *Albert G. Holzman Distinguished Educator Award* in 2005.

19. I served as an appointed member of the National Institutes of Health (NIH) Consensus Development Panel on "Noise and Hearing Loss" in 1990, which authored the NIH statement on this subject. It was subsequently published in the *Journal of the American Medical Association*, 1990, *263*(23), 3185-3190, entitled "Noise and Hearing Loss." I was elected as President of the National Hearing Conservation Association (NHCA) for 2007 and have since served on its

Leadership Advisory Team. In 2009, I received the NHCA's *Outstanding Hearing Conservationist Award*, and I have twice received NHCA's *Outstanding Lecture Award*, as well as the *Media Award*.

20. In 2014, I received, in conjunction with former Ph.D. student and co-author Lt. Colonel Kristen Casto of the U.S. Army, the *Joseph L. Haley Writing Award* from the Aerospace Medical Association - Army Aviation Medical Association, for the best helicopter-related aerospace medicine publication in any media for the year 2013, in recognition of our paper in the *Human Factors Journal, 2013, 55*(3) 486-498, entitled "Effects of Headset, Flight Workload, Hearing Ability, and Communications Message Quality on Pilot Performance." This paper analyzed hearing protective headsets as used in the U.S. military's Blackhawk helicopter cockpit.

21. In 2016, I received the *Safe-in-Sound Award* at the NHCA international conference, awarded through a partnership between NIOSH and NHCA, for research on auditory situation awareness and development of test systems and protocols for assessing the effects of hearing protection and headphone devices on auditory situation awareness.

22. Most recently, in recognition of my work outside the university setting, I received the 2020 *Dean of Engineering Award for Excellence in Outreach* at Virginia Tech for providing engineering assistance to the community,

businesses, and other entities. I am also a member of the *Virginia Tech Outreach Academy of Excellence.*

23. I have served, or am currently serving, as a member of five American National Standards Institute (ANSI) Committees, as well as several other standards committees for other organizations, such as the U.S. Technical Advisory Group (TAG) to the International Standards Organization Technical Committee 159 (Ergonomics). Four of the ANSI committees are/were directly related to hearing protection device testing. I also played a large role in the development of the Method B (inexperienced subject fit) provisions of ANSI S12.6-1997, subsequently revised in several later versions and currently identified as ANSI S12.6-2016.

24. I have been an invited presenter or participant at meetings, conferences, and hearings organized by Defense Advanced Research Projects Agency (DARPA), North Atlantic Treaty Organization (NATO) Aerospace Medical Panel, National Academy of Engineering, National Institutes of Health, National Fire Protection Association, American Psychological Association, Transportation Research Board, EPA, NHCA, Human Factors and Ergonomics Society, and the Institute of Industrial Engineers, among other organizations.

D. Patents and Publications

25. I am an inventor or co-inventor on seven United States utility patents and one European patent. Five of these patents relate directly to hearing protection or other in-ear devices.

26. I have published approximately 155 journal and proceedings articles, 70 various other papers, 28 book chapters, 40 technical reports for government and military agencies, and 88 technical reports for companies. The majority of my articles and chapters relate specifically to human hearing, noise and/or hearing protection issues.

E. Consulting and Outreach Outside the University

27. Through H.E.A.R. LLC (and prior to that as a sole proprietor), I have served as a paid consultant on over 150 projects and other efforts for over 60 companies (including Bose Corporation as one of many hearing-related product companies), government agencies and law firms on various human hearing, hearing protection design and testing, noise, safety and ergonomics issues.

28. Under Virginia Tech's outreach mission, I have provided pro bono assistance on over 60 separate efforts to communities and agencies outside the university. The latter includes a lead role for two municipalities in drafting and assistance with the promulgation process for noise ordinance legislation.

29. I have also provided approximately 50 outreach workshops, short courses and seminars to professional organizations, government/military agencies, and universities.

30. I have also consulted for a variety of public, private and governmental entities on issues relating to the design of headsets. A few examples follow. In 2017, I did proprietary company design work on insert earphones addressing comfort, attenuation and range of fit issues. Over a period of several years during the 2000 decade, I assisted Custom Protect Ear on various in-ear device design and performance issues, including hearing protectors and communications headsets. Starting in 2007, I was a Scientific Advisory Board member for Personics, Inc., a hearing protection and headphone company, for which I consulted on product design and patenting. In 2008-09, I consulted for Shure Corporation on earphone design issues. In 2002, I performed testing of a circumaural radio headset for Swedish company Peltor AB. In 1994, I consulted for Noise Cancellation Technologies on issues relating to an active noise cancellation headset. In 1993, I consulted for Booz-Allen & Hamilton, Inc. on active noise cancellation headsets. Additional consulting experience for headset and other ear-related technologies are listed in my CV (Ex. 1006).

F. Teaching and Advising at Virginia Tech

31. I have taught seven different courses at Virginia Tech, and developed four of them, including courses in *Human Factors in Systems Design*, *Human Audition, Noise, and Auditory Displays*, *Forensics and Litigation for Human Factors Engineers,* and *Introduction to Human Factors Engineering.*

32. I have taught human factors in product and systems design for 38 years, emphasizing the importance of evaluating and accommodating human capabilities, limitations, and physical, psychological, and sensory/perceptual characteristics in the design of human-machine systems and products to improve the safety, efficiency, and usability of these systems. I have taught courses at the Master's (M.S.) and Doctoral (Ph.D.) level. For example, my *Human Factors in Systems Design* course entails the complete design process using a human-centered design philosophy, and relying on several example projects in product design and public system design. The centerpiece project of this course requires the students to redesign a headband-mounted, in-ear product that couples to the ear's concha bowl and ear canal aperture regions of the pinnae. My *Human Hearing and Auditory Display Design* course covers sound and noise and its measurement; human hearing and its measurement, injury, protection, and compensation; auditory display and warnings design; consensus standards for product testing; and ear-related product design and testing.

33. I have been faculty chairman (*i.e.*, major advisor) for 25 Ph.D. and 31 Master's students who have completed degrees to date. Of the 25 Ph.D. students, eight were U.S. military officers who came to Virginia Tech to study with me, three were U.S. military civilian employees, and three were military audiologists per prior training and practice. Seven of these military-affiliated Ph.D. students worked on hearing protection and headset research problems under my direction.

II. MATERIALS REVIEWED AND CONSIDERED

34. My opinions provided in this declaration are based on my years of education, research, experience, and background in the field of headphone assembly design, as well as my investigation and study of relevant materials for this declaration. When developing the opinions set forth in this declaration, I assumed the perspective of a person having ordinary skill in the art of headphone assembly design, as set forth in Section V below. In forming my opinions, I have studied and considered the materials identified in the list below and any other materials referenced or cited in my declaration.

Exhibit	Description
1001	U.S. Patent No. 10,206,025
1002	Prosecution History of U.S. Patent No. 10,206,025
1016	U.S. Patent Application Publication No. 2007/0165875 ("Rezvani-875")
1017	U.S. Patent No. 6,856,690 ("Skulley")
1020	U.S. Patent Application Publication No. 2008/0076489 ("Rosener")
1023	U.S. Patent Application Publication No. 2007/0253579 ("Liu")
1024	U.S. Patent No. 7,627,289 ("Huddart")

1025	U.S. Patent No. 5,889,870 ("Norris")
1026	U.S. Patent Application Publication No. 2008/0031475 ("Goldstein")
1027	IEEE Std. 315, Graphic Symbols for Electrical and Electronic Diagrams (1975) (Reaffirmed 1993)
1033	U.S. Patent No. 5,761,298 ("Davis")
1035	U.S. Patent No. 6,295,366 ("Haller")
1041	U.S. Patent Application Publication No. 2007/0149261 ("Huddart-2")
1042	U.S. Patent No. 8,180,078 ("Zellner")
1048	Internet Archive of http://www.bose.com/controller?event=VIEW_PRODUCT_PAGE_EVENT&product=headphones_audio_subcategory (Nov. 1, 2007)
1049	U.S. Patent Application Publication No. 2007/0092098 ("Kaderavek")
1050	U.S. Patent Application Publication No. 2008/0226094 ("Rutschman")
1076	Skrainer, S. F., Royster, L.H., Berger, E.H., & Pearson, R. G. "Do Personal Radio Headsets Provide Hearing Protection," Sound and Vibration, 19(5), (1985), 16-19
1077	Casali, J. G. & Park, M. Y., "Attenuation performance of four hearing protectors under dynamic movement and different user fitting conditions," Human Factors, 32(1), (1990), 9-25
1078	U.S. Patent No. 7,564,989 ("Schanz")
1097	U.S. Patent Application Publication No. 2007/0136446 ("Rezvani-446")
1099	PCT Publication No. WO 2006/098584 ("Oh")
1101	U.S. Patent No. 7,072,686 ("Schrager")
1113	U.S. Patent No. 4,456,795 ("Saito")
1127	U.S. Patent No. 6,097,809 ("Lucey")
1135	U.S. Patent Application Publication No. 2002/0041697 ("MacDonald")

III. SCOPE OF MY OPINIONS

35. The conclusions and opinions that I have expressed in this declaration are my own, and of my own formulation and expression. My conclusions and opinions are based on my education, experience, and background in the technical

fields and areas of endeavor discussed below in Section V regarding the person of ordinary skill in the art ("POSA"), with the understanding that my expertise would be at the expert level, not at the POSA level.[5] I hold these conclusions and opinions to a reasonable degree of scientific certainty.

36. I understand that Bose has engaged another expert, Dr. Tim Williams, to provide opinions on issues relating to the wireless communications aspects of the challenged claims. I have not been asked to provide opinions on these topics and have not discussed or reviewed Dr. Williams's expert declaration or any drafts of his declaration. Instead, I have been asked to provide an overview of the state of the art of the non-wireless communication aspects of wireless headphone assembly design by 2008, such as the known form-factor options for a wireless headphone assembly and the extent to which a product designer with experience with headphone assembly design and working in a collaborative team with a person having experience with wireless functionality (*see* Section V below for a description of a POSA) would have had reasons to design, and a reasonable

[5] As I note in Paragraph 43 below, when I refer to "POSA" in this declaration I am referring to the engineer or product designer with headphone experience that collaborates in a team with a person having experience in wireless technology, as I discussed in Section V below.

expectation of success in designing, a wireless headphone assembly using each of the form factors that I discuss in more detail below in Sections VI, VIII-IX.

IV. MY UNDERSTANDING OF RELEVANT PRINCIPLES OF PATENT LAW

37. In developing my opinions, I discussed various relevant legal principles with Petitioner's attorneys. I understood those legal principles when they were explained to me and have relied upon those legal principles, as explained to me, in the course of forming the opinions set forth in this declaration. My understanding in this respect is as follows:

38. I understand that "*inter partes* review" (IPR) is a proceeding before the United States Patent & Trademark Office for evaluating the patentability of an issued patent's claims based on prior-art patents and printed publications.

39. I understand that, in this proceeding, Petitioner has the burden of proving that the challenged claims of the '025 patent are unpatentable by a preponderance of the evidence. I understand that "preponderance of the evidence" means that a fact or conclusion is more likely true than not true.

40. I understand that, in IPR proceedings, claim terms in a patent are given their ordinary and customary meaning as understood by a POSA in the context of the entire patent and the prosecution history pertaining to the patent. If the specification provides a special definition for a claim term that differs from the meaning the term would otherwise possess, then the specification's special

definition controls. I have applied these standards in preparing the opinions in this declaration.

V. PERSON OF ORDINARY SKILL IN THE ART

41. I understand from Petitioner's attorneys that Petitioner proposes that a POSA would principally have had a background in wireless networks, including at least a bachelor's degree in electrical engineering or a related field and experience with wireless networks. A POSA would have been a member of a team including an engineer or product designer with experience in headphone design.

42. I agree that in the art of headphone assembly design for a wireless headphone assembly, a person would have a background in wireless technology and, if that person did not have sufficient experience with headphone design, would have been a member of a team including at least one other person with a background in engineering or product design bringing experience in headphone design.

43. I have been informed and understand that for purposes of discussing the state of the prior art, my opinions should be provided from the perspective of the engineer or product design person described above in Paragraph 41 who would have worked in a collaborative team with a person with a background in wireless technology, based on the understanding of that engineer or product design person at the time of the patent claim's alleged priority date, which I have been asked by

Petitioner's attorneys to assume is April 7, 2008. However, the opinions I offer in this declaration about the background knowledge of a person of ordinary skill would not change even if I were to consider a priority date of January 2007. I have been informed and understand that the person of ordinary skill in the art of headphone design is presumed to be aware of all pertinent prior art and the conventional wisdom in the art, and is a person of ordinary creativity. I have applied this standard throughout my declaration and, unless otherwise stated, when I refer to a "POSA" throughout the remainder of this declaration, I am referring to that engineer or product designer with headphone design experience who would have worked in the collaborative team, as described above in Paragraph 41.

44. By 2008, I held a Ph.D. in Industrial Engineering and Operations Research (Human Factors Concentration), and at that time I had over 25 years of experience with issues relating to the design of ear-worn devices, inclusive of headphone assemblies. Therefore, I was a person of more than ordinary skill in the art of headphone design during the relevant timeframe. However, I worked with many people who fit the characteristics of an engineer or product designer with headphone design experience, and I am familiar with their level of skill and used that person's perspective when developing the opinions set forth in this declaration.

45. As I explain in more detail in Section VI below, using their ordinary skill and working in the collaborative team described in Paragraph 41 above, a POSA understood by 2008 that functional aspects of a wireless headphone assembly (*e.g.*, the processors and transceivers for wireless communication) could have been incorporated into any of the general types, which I will herein refer to as 'form factors' in my descriptions. Indeed, by 2008, headphone assemblies in each of the form factors below had been available in the consumer market. *See* Paragraph 51 below.

VI. OVERVIEW OF HEADPHONE ASSEMBLY DESIGNS

46. Below I provide an overview of conventional headphone assembly designs and form factors that would have been known to and considered by a POSA when designing a wireless headphone assembly by 2008.

A. Earphones and Loudspeakers

47. A headphone includes at least one earphone. As I discuss in more detail in Sections VI.B.1-VI.B.3, below, an earphone can, in general, be of three types: in-the-ear, on-the-ear (supra-aural), and over-the-ear (circum-aural). An earphone in general includes at least one loudspeaker (which is one type of acoustic transducer, and is often termed "speaker"). *See Norris* (Ex. 1025), 2:6-9 (a "speaker is a transducer"). A single earphone which is worn on one ear is a common type of monaural (also called "mono") design, and monaural can also be

configured in designs with two earphones, with the same signal supplied to both earphones. However, to take advantage of stereo audio, a headphone requires two earphones, with each earphone receiving a *separate* audio signal. When both earphones receive and output different signals, as in stereo presentation, it is called "dichotic," as opposed to both earphones receiving and outputting the same signal, called "diotic." Whereas the two audio signals in a stereo signal can be recorded by microphones separated by a set distance, a dual-earphone stereo headphone can also playback binaural recordings, which are separate audio signals recorded on either side of a head (artificial or real). This is corroborated, for example, by Ex. 1017 ("Skulley") (*see also* Section IX.C below discussing Skulley), which identifies as Background information that "headset[]" (*i.e.*, headphone) designs by its 2002 filing date had "one or two earphones for monaural or stereo listening," respectively. *See Skulley* (Ex. 1017), 1:22-23. I will generally refer to a headphone with one or two earphones synonymously as a "headphone," unless otherwise stated. In a monaural headphone, only a single earphone and (optionally) a microphone (for example *Skulley* (Ex. 1017), 1:11-12), are required, and this one-earphone configuration is generally preferred over a two-earphone design when a user wants to be aware of and interact with their surroundings, *e.g.*, a call-center operator listening to customers on the phone, but who also wants to be able to hear nearby co-workers or auditory warning signals (*e.g.*, for increased situational awareness). However, as Liu ("Ex. 1023") at [0004] notes "[m]ono headsets... are not suitable for listening to stereo music." Stereo designs are especially preferred over monaural designs when a user wants to hear high-fidelity music from at least two independent channels, and this configuration is usually applied to create an auditory perception that the sounds are originating from various directions or spatial perspectives. Thus, unlike monaural design, stereo headphones *must* have two earphones, at least two speakers (one in each earphone) and (optionally) a microphone, the microphone typically serving to receive user speech. Another advantage of having two separate earphones, and especially those of circum-aural design which cover the pinnae, is to attenuate (reduce) ambient noise by having the headphone produce the desired sounds directly in both ears, while attenuating unwanted environmental sound. Furthermore, two-earphone designs are sometimes preferred for voice applications where the intelligibility (*i.e.*, the understanding) of voice communications is at high priority, such as in an aircraft cockpit, broadcast booth, race car cockpit or telephone answering centers (or other noise environments that create masking interference). And for music applications, Liu ("Ex. 1023") at [0005] corroborates, "[s]tereo headsets are mostly used when users wish to listen to music as they have two earphones for creating stereo sound." *See also* Ex. 1024 ("Huddart"), 1:7-15 ("[T]here are certain usage scenarios in which the user of a wireless communication headset may wish to listen to a stereo signal using both ears. Such usage scenarios are expected to increase with the availability of a variety of electronic devices and multi-function devices."). Sometimes, stereo headphones will incorporate more than one speaker in each earphone, and this is typically to provide higher sound fidelity. Because most humans hear with two ears, stereo headphone assemblies are the most common configuration at least for most leisure use cases and, thus, in many contexts the term "headphone" is meant to include two earphones, with at least one speaker in each earphone. *See, e.g.*, Ex. 1026 ("Goldstein"), [0048] (headphones "are a pair of transducers").

48. Thus, by 2008, a POSA would have had several reasons to implement a wireless headphone assembly with two earphones (*e.g.*, as in a stereo design, with two earphones, each having an associated speaker and a unique signal input). First, as I explained in Paragraph 47 above, stereo designs were preferred for headphones intended for music rendition, in particular high-fidelity music playback that generally has binaural auditory imaging from different apparent locations. In contrast, single-earphone headphones (or even two-earphone monaural headphones) cannot produce high-fidelity stereo audio because stereo sound reproduction requires that both ears receive separate audio signals that have been processed to produce stereo separation. This is corroborated, for example, by Ex. 1020 ("Rosener"), [0009], which states that "monaural" headsets are

"incapable of providing high-fidelity stereo audio to the user." Thus, headphones intended for playback of high-fidelity music would have likely been designed in a stereo (two-channel / two-earphone / two-speaker), not a one-earphone / one-speaker design. Second, by 2008, it would have been using a known technique (stereo design) in a known apparatus (wireless headphone assembly) for a known benefit (reproducing sound with stereo separation). Third, as I explained in Paragraph 47 above and above in this paragraph, with respect to the number of earphones and speakers, by 2008 there was a finite number of options—with two earphones and (at least) two speakers being one of the most common of those options in a stereo configuration.

49. By 2008, a POSA would have understood that it only required ordinary skill to implement a wireless headphone assembly using two earphones, and each having at least one speaker. By 2008, for example, it was well-known and common to playback two unique stereo signals in a headphone from two distinct earphones to provide an auditory rendition of the stereo separation of the two signals. By 2008, in fact, each of the form-factors I discuss in more detail below in Section VI.B were known and commercially available in two-earphone (stereo) designs. From the perspective of the earphone(s)'s overall form factor (*i.e.*, on-the-ear vs. in-the-ear vs. over-the-ear level, to be explained next in Section VI.B), by 2008, converting an earphone between wired and wireless designs only

required a POSA's ordinary skill because the high-level form factor for the earphone design was largely independent of the choice between a wired or wireless (or "fully wireless," *see* Section VI.C below) design.

B. Form Factors for the Housing Structure for Headphones

50. Another design consideration for headphone assemblies is the overall form factor of the assembly itself—*e.g.*, the physical design of the body and earphones' housing. For the purposes of this declaration, the earphone "housing" refers to the physical structure of an earphone that encloses (houses) or otherwise holds and locates, the earphone's component parts. As Skulley corroborates as part of its background information, by 2008, it was known that both monaural and stereo headphone designs "can be classified into ***three general types***[6] in accordance with the type of ear-phone that they employ: 1) '***In-the-ear***' type [intra-aural] earphones, sometimes referred to as 'ear buds,' which fit into the concha, or entrance to a wearer's middle ear,[7] such as that described in U.S. Pat.

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[6] All bold and italicized emphasis has been added, unless noted otherwise.

[7] "Middle ear" technically refers to the conductive part of the ear between the tympanum (eardrum) and the stapes bone which communicates with the "inner" or neural part of the ear, and does *not* refer to the outer ear as it is presented here by Skulley (Ex. 1017). However, given that this anatomical region is inaccessible to

No. 5,761,298 to M. Davis, et al." ("Davis," Ex. 1033), which illustrates an in-the-ear design with a support structure (*e.g.*, earhook 13, *see Davis* (Ex. 1033), 4:40-41) that wraps around and behind the ear; "2) '***On-the-ear***' types [supra-aural] that couple against a lateral face of the auricle [also known as pinna], or external ear, of the wearer, such as that described in U.S. Pat. No. 5,960,094 to W. Jensen, et al.; and, 3) ***'Over-the-ear***' types [circum-aural] that surround and form a closed chamber over the auricle of the listener, such as that described in U.S. Pat. No. 6,295,366 to L. Haller, et al." ("Haller," Ex. 1035). *See Skulley* (Ex. 1017), 1:22-34. Again, these general types can be termed "form factors," which I will illustrate and address in Paragraphs 51-52 below.

51. I agree with Skulley that by 2008 each of these headphone designs was a well-known, common configuration for use with a headset assembly. *See Skulley* (Ex. 1017), 1:11-13, 1:22-34. By 2008 headphone products were actually sold in the consumer market in all three design options, oftentimes with the same company offering the same or comparable functionality in multiple form-factors. For example, the following is a screenshot of a page from Bose Corporation's website captured by the Internet Archive on November 1, 2007, showing

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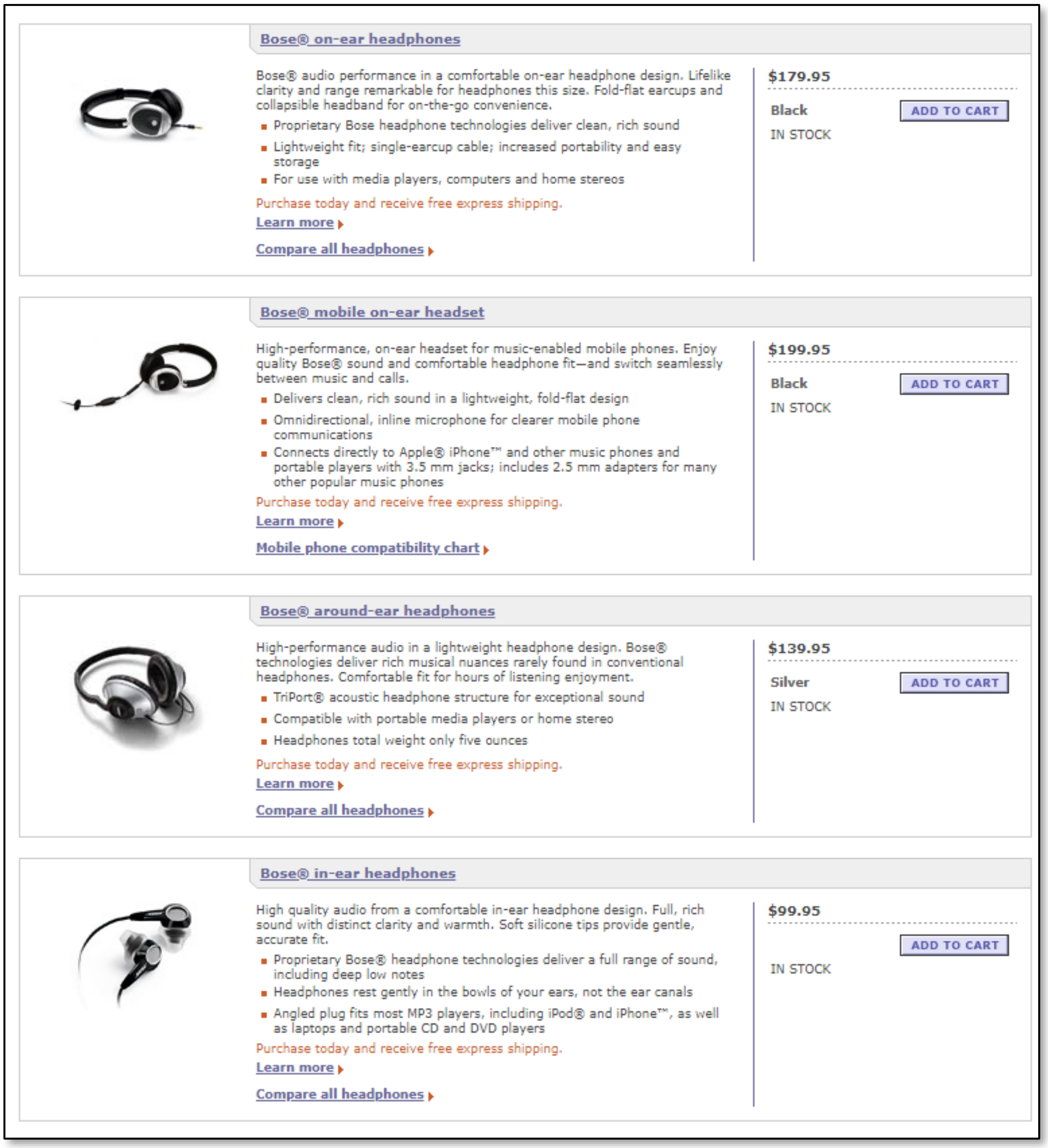
an earphone, a POSA would have understood Skulley to be referring to the user's ear canal, which is indeed part of the outer ear.

headphone assemblies in on-the-ear (the first two headphones from the top of the image), around-ear (*i.e.*, over-the-ear) (the third headphone from the top) and in-the-ear (*i.e.* earbud) designs (the bottom headphone):



Ex. 1048 (Internet Archive of page on Bose.com (Nov. 1, 2007)).

52. As I discuss in more detail in Sections VI.B.1-VI.B.3 below, these headphone form factors had known tradeoffs along a variety of dimensions, such

as sound quality, sound attenuation, aesthetics, weight, ease of fitting and comfort. *See Skulley* (Ex. 1017), 1:22-34 (describing the three form factors); *Rosener* (Ex. 1020), [0010] ("Each of the various types of prior art headsets described above has its own unique benefits and drawbacks."). For that reason, by 2008, a POSA had reasons to design a wireless headphone assembly in *each* of these form factors, as I discuss in more detail in Sections VI.B.1-VI.B.3 below. And as I discuss in more detail below in Sections VI.B.1-VI.B.3, by 2008, it required only ordinary skill to implement a wireless headphone assembly in each of these form factors.

1. On-The-Ear (Supra-Aural) Design

53. Figure 1 (copied below) of Kaderavek (Ex. 1049) illustrates a prior art on-the-ear design that further includes a headband 102 (*see Kaderavek* (Ex. 1049), [0034]) (I discuss headbands in more detail below in Section VI.B.4). This design may alternatively be a circum-aural design if the earpiece 110 "completely surrounds the ear." *Kaderavek* (Ex. 1049), [0039].

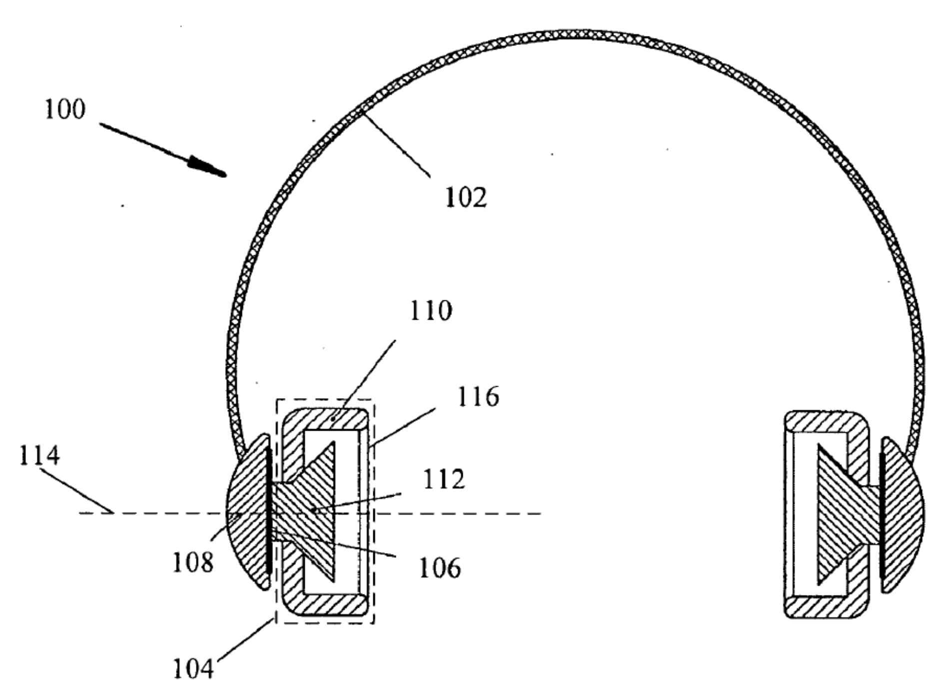


Figure 1

54. On-the-ear designs are sometimes also referred to as supra-aural headphones because, as shown in the figure above, they are designed to rest on (*e.g.*, with an earpad) / above ("*supra*") the user's ear. However, on-the-ear designs (unlike over-the-ear designs, *see* Section VI.B.2 below) are not intended to completely enclose the user's ears by encircling the pinnae, as are circum-aural designs. For that reason, in general, on-the-ear headphones are smaller and lighter than over-the-ear designs (*see* Section VI.B.2 below), but generally larger and heavier than in-the-ear (earbud) designs (*see* Section VI.B.3 below). Supra-aural headphones also typically incorporate a headband, which connects the earphones

and it usually is configured to provide a compression force to help hold the earphones against the pinnae, as I discuss in more detail in Section VI.B.4 below.

55. There are many reasons why a POSA would have wanted to implement a wireless headphone assembly in an on-the-ear design. First, because they are smaller than over-the-ear designs, on-the-ear designs are generally lighter and easier for the user to carry compared to over-the-ear designs; however, on-the-ear designs are generally not as small as in-the-ear designs and so are not as easily misplaced or lost as in-the-ear headphones. Second, because on-the-ear designs are lightweight and do not generally provide a seal against the head or ear, they do not provide significant isolation from or passive attenuation of external noise.[8] Third, some users *may* find on-the-ear headphones to be the most comfortable design because on-the-ear designs do not require inserting a device *into* the user's ear canal or concha bowl (as with in-the-ear designs) which often causes some distortion of cartilaginous tissue, and they are also generally lighter in weight and do not completely envelop the user's ears (as compared to over-the-ear designs). Fourth, as compared to in-the-ear designs, on-the-ear (and over-the-ear) designs

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[8] Ex. 1076 (Skrainar, S. F., Royster, L.H., Berger, E.H., & Pearson, R. G. "Do Personal Radio Headsets Provide Hearing Protection," *Sound and Vibration*,1985, *19*(5), 16-19).

generally have a headband connecting two earphones, which helps maintain the earphones against the user's ear and may thus be less-likely to move (or fall off) compared to certain in-the-ear designs that are not compatible with the contours of the user's ear canals or conchae (*e.g.*, there are many construction material and design factors that contribute to headphone fit quality and stability, but for instance, certain in-the-ear designs tend to loosen in the ear canal when the user is moving vigorously and/or sweating). *See, e.g.*, Ex. 1077[9]; *Skulley* (Ex. 1017), 1:35-38 (teaching as background knowledge that on-the-ear and over-the-ear design "types[] typically incorporate some structure, such as a yoke or headband, for forcefully maintaining the output face of the earphone in, against, or over the ear of the wearer"). Fifth, a POSA would have known that some people preferred the look of on-the-ear designs compared to over-the-ear and in-the-ear designs. Sixth, the combination of a relatively small earphone diameter with a thin headband offered feasibility for an on-the-ear design to have the advantage of being stored around the neck when not in use. Seventh, as I have explained above,

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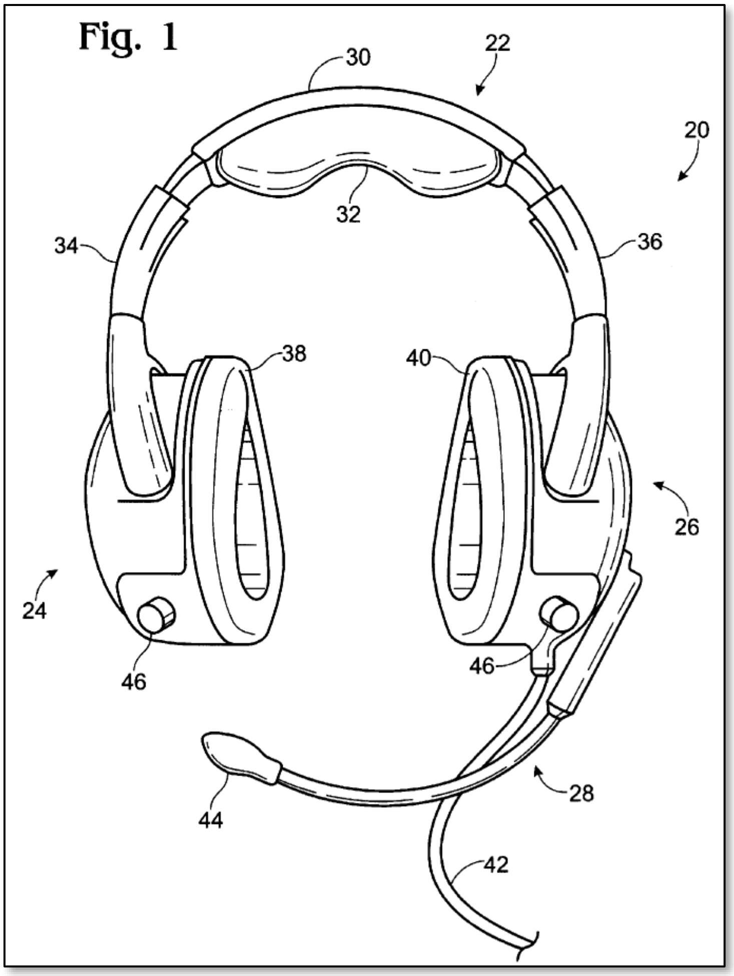
[9] Ex. 1077 (Casali, J. G. & Park, M. Y., "Attenuation performance of four hearing protectors under dynamic movement and different user fitting conditions," *Human Factors*, 1990, *32*(1), 9-25).

on-the-ear designs were one of a finite number of design options for a headphone assembly (including on-the-ear, over-the-ear, and in-the-ear designs).

56. By 2008, a POSA would have understood that the components of a wireless headphone assembly in an over-the-ear or in-the-ear design could have been incorporated into the housing of an on-the-ear design using ordinary skill. Adapting an over-the-ear design to an on-the-ear design would have required only ordinary skill because over-the-ear components are generally larger or comparatively-sized to those of on-the-ear designs, and to the extent any additional space was needed in the on-the-ear design, certain components could be enclosed in earphone housings that are increased in dimension, usually either in diameter or thickness. Similarly, it would have only taken ordinary skill to adapt an in-the-ear design to an on-the-ear design because an on-the-ear design generally has more room to fit the similar functional components of the in-the-ear design.

2. Over-The-Ear (Circum-Aural) Design

57. As explained above, another well-known form factor for headphone assemblies by 2008 was over-the-ear design. Over-the-ear designs are also referred to as circum-aural ("around the ear") headphones because they completely surround, encircle, and enclose the user's ears. Figure 1 of Haller (Ex. 1035) illustrates a typical over-the-ear headset design (in this case with a microphone pickup element carried in a microphone housing 44). *Haller* (Ex. 1035), 3:2-3.



58. Similar to the example illustrated in Figure 1 above, on-the-ear designs typically have large circular or ellipsoidal earpads (reference number 38 and 40 in Figure 1, termed therein as a "seal" (*Haller* (Ex. 1035), 2:64-67) that are usually made of a soft, compliant material that encases a foam or liquid/gel inner lining to comprise a cushion, with said cushion's seal interfacing with the flesh of the head around the pinna. *See, e.g., Haller* (Ex. 1035), 3:38-43. The combination of the sealing provided by seals 38 and 40, with the noise-blocking structure and enclosed airspace of ear cups 24 and 26, and the compression force provided by headband 22 and ear cup supports 34 and 36, yields an integrated configuration

that is sometimes designed specifically to attenuate ambient noise by passive means (as opposed to using electronic signal processing-based, active noise cancellation techniques). *See, e.g.*, *Haller* (Ex. 1035), 1:34-38. I further note that hybrid devices incorporating both of the aforementioned passive attenuation designs with electronic active noise cancellation were known in the art by 2008.

59. There were several reasons why a POSA would have wanted to offer a headphone assembly in an over-the-ear design. First, because over-the-ear designs completely surround the user's ear they were readily configurable to provide passive sound attenuation and thus generally known to offer better noise exclusion than on-the-ear designs. Some of the noise-reduction benefits are the direct result of the physical design as mentioned above in Paragraph 58, without requiring active noise cancellation circuitry, thus allowing for reasonable levels of attenuation at comparatively lower cost than with the advanced signal processing and battery power required for active noise reduction. Second, by completely surrounding the user's ears, an over-the-ear design provided some extra protection from the elements during cold or windy days compared to on-the-ear and in-the-ear designs. Over-the-ear designs, assuming a proper cushion design and sufficient headband compression and resultant cushion pressure against the head, also have good potential for maintaining the earphones' position on the ear and head, as compared to on-the-ear headphones or in-the-ear inserts, both of which may more

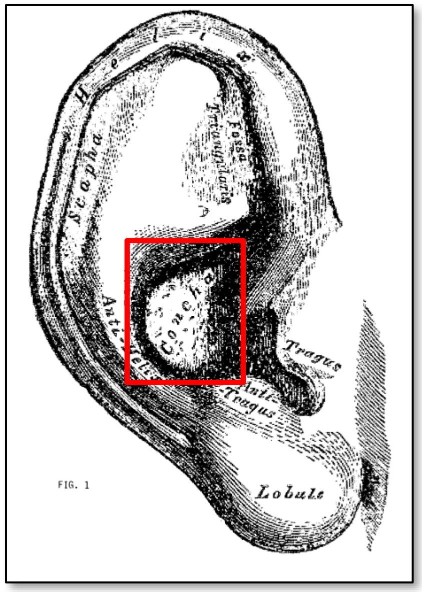
readily change position during exercise and g-forces imparted to the head. Third, a POSA would have known that certain people preferred the look of over-the-ear designs compared to on-the-ear and in-the-ear designs, simply as a matter of style and personal preference. In relation to this latter point, the over-the-ear design also offers more surface area for style feature display, such as color or logos. The volume encased within the ear cup cavity of the over-the-ear design can be used to hold the various electrical components of the headphones (*e.g.*, batteries, amplifiers, loudspeakers, receivers, etc.). (Though by the mid-2000s it was also common for on-the-ear and even in-the-ear earphones to house the electrical components. *See, e.g.*, *Goldstein* (Ex. 1026), FIG. 5A-5B, [0069]-[0070] (describing in-the-ear design), discussed further Section IX.G below). Fifth, as I have explained above, an over-the-ear design was one of a finite number of design options for a headphone assembly (including on-the-ear, over-the-ear, and in-the-ear designs).

60. By 2008, a POSA would have understood that components in a wireless headphone assembly in an on-the-ear or in-the-ear design could be incorporated into the housing in an over-the-ear design using ordinary skill. Adapting an on-the-ear design to an over-the-ear design would have required only ordinary skill because over-the-ear components are generally larger or comparatively sized to those of on-the-ear designs. And it would have only taken

ordinary skill to adapt an in-the-ear design to an over-the-ear design because an over-the-ear design generally has more space inside its housing to fit similar functional components found in an in-the-ear design.

3. In-the-Ear (Earbud) Design

61. The third common and conventional form-factor for headphone assemblies in the prior art was in-the-ear headphone design. In-the-ear types were also often referred to as "earbuds" because they are intended to be placed near to or partially inside the ear canals of the user, or at least inside the concha bowl of the outer ear. Some in-the-ear designs have a portion that is both inserted into a user's ear canal and a portion that rests within the concha of the user's ear. Other versions of in-the-ear designs are intended to fit more deeply into the ear canal to provide better sound attenuation (*i.e.*, isolation of ambient noise), and better security of fit during movement. *See, e.g., Rosener* (Ex. 1020), [0007] ("An earbud is a small headphone that fits into the concha of the pinna of the user's ear."). An ear's "concha" is illustrated below, and it is essentially the bowl-shaped depression of the pinna:



Schanz (Ex. 1078), FIG. 1.

62. An example of in-the-ear designs (earphones 502 and 504) is illustrated below in Rosener's (Ex. 1020) Figure 5:

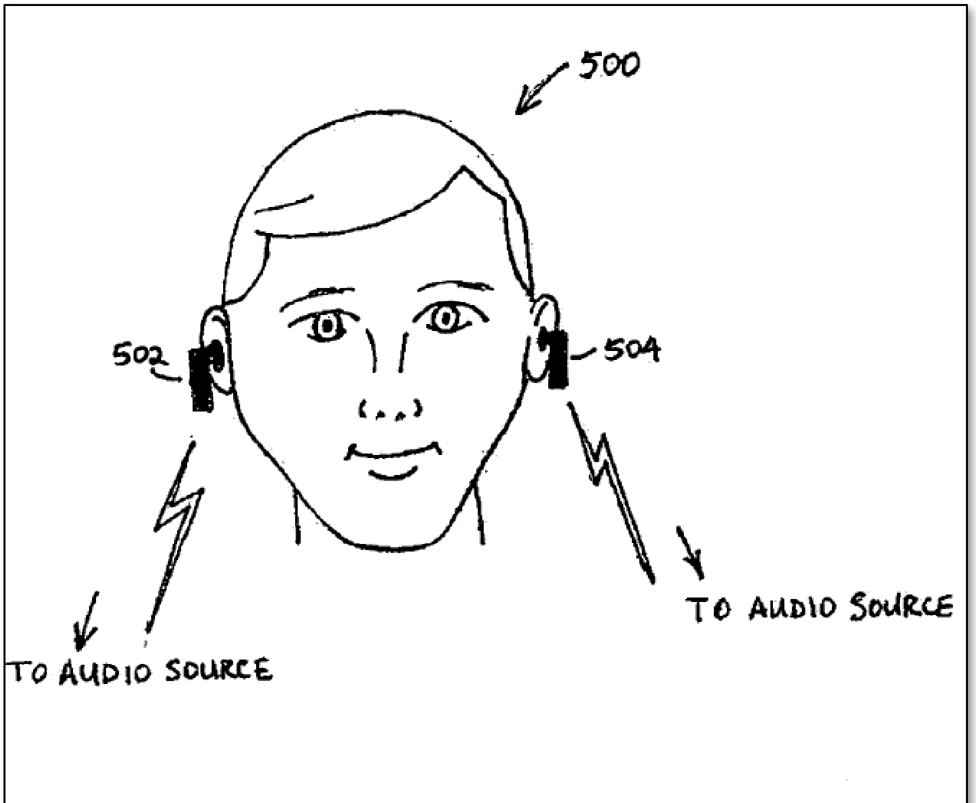
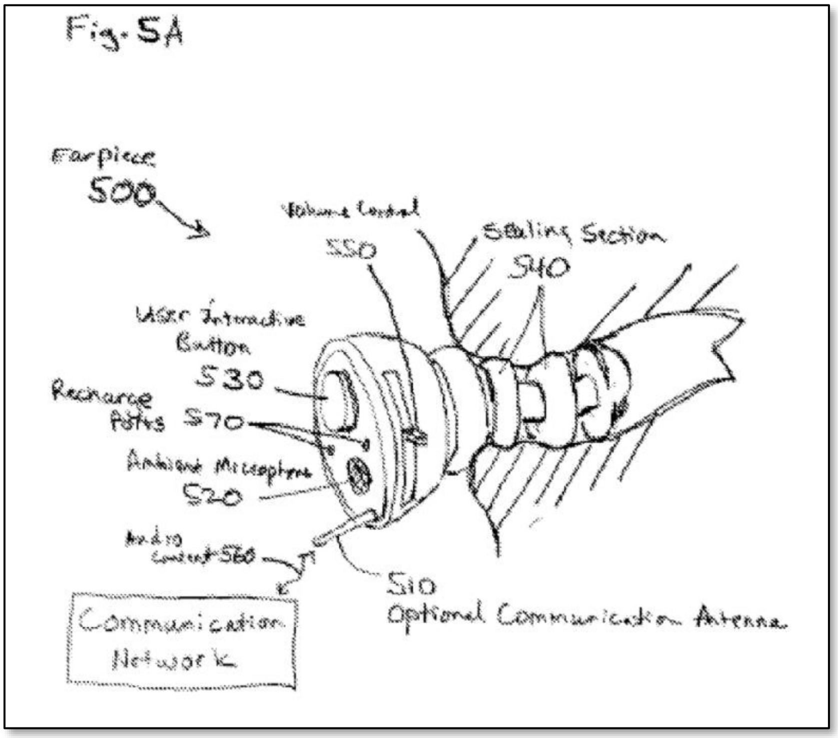


FIGURE 5

Rosener (Ex. 1020), [0030] ("Each of the first and second earphones 502, 504 may be in the form of an earbud designed to fit into the concha…."). As illustrated above, earphones 502 and 504 "may be in the form of an earbud designed to fit into the concha of the pinna of the user's ear" and each having "a housing containing a speaker" and other components (*e.g.*, a battery). *Rosener* (Ex. 1020), [0030]. As shown in Fig. 5, the earphones have an elongated "housing" portion that extends vertically from the "earbuds" that fit into the concha. *Rosener* (Ex. 1020), [0030].

63. Another example of an in-the-ear earphone is illustrated in Goldstein's (Ex. 1026) Figure 5A below (*see also* Section IX.G below):



64. By 2008, a POSA would have had several reasons to implement a headphone assembly in an in-the-ear design. First, a POSA would have understood that some users would have preferred the small form factor of earbuds because they are generally lighter, smaller and less obtrusive than on-the-ear and over-the-ear designs, and typically small enough to be carried in a user's pocket or small purse, unlike conventional on-the-ear and over-the-ear designs. As Davis (Ex. 1033) corroborates, "[n]aturally, it is desirable to utilize microphones and receivers of the smallest possible size and least weight, making the resulting headset as light and compact as possible" (1:67-2:3), which in-the-ear designs achieve because they generally allowed for small form factors. Second, as noted in Paragraph 61 above, earbuds can be designed to fit snugly into the concha or rather deeply into the user's ear canal to provide improved sound delivery (*i.e.*, reduce the loss of sound reaching the user's tympanic membrane) and noise reduction properties (*i.e.*, attenuation of ambient noises) as compared to on-the-ear designs, if fitted properly. As Davis (Ex. 1033) corroborates, "an earbud that is placed in the concha" is "typically to provide a better acoustic coupling to the ear canal" (2:30-32). Third, as with any design of a commercial product, some users preferred the look of in-the-ear designs or found them more convenient to use while wearing headgear (*e.g.*, a baseball cap, goggles, or hardhat/helmet). Fourth, as I've explained above in Paragraph 50, an in-the-ear design was one of a finite number

of design options for a headphone assembly (including on-the-ear, over-the-ear, and in-the-ear).

65. By 2008, it would have required only ordinary skill to adapt a wireless headphone assembly in an on-the-ear or over-the-ear design to an in-the-ear earbud design by reducing the size and/or changing the configuration of functional components in a known fashion. A POSA would have known (working in the collaborative team discussed above in Section V) that the functional components of a wireless headphone assembly (the antennas, processors, transceivers, and batteries) were by then small enough to fit within the housings of in-the-ear designs. This is corroborated, for example, by Rosener, which discloses a pair of completely wireless in-the-ear earphone design. *See Rosener* (Ex. 1020), FIG. 5, [0030]. Similarly, as I discuss further below in Section IX.G, Goldstein similarly discloses an in-the-ear design where the electrical components are in the earphone. *See, e.g., Goldstein* (Ex. 1026), FIG. 5A-5B, [0069]-[0070].

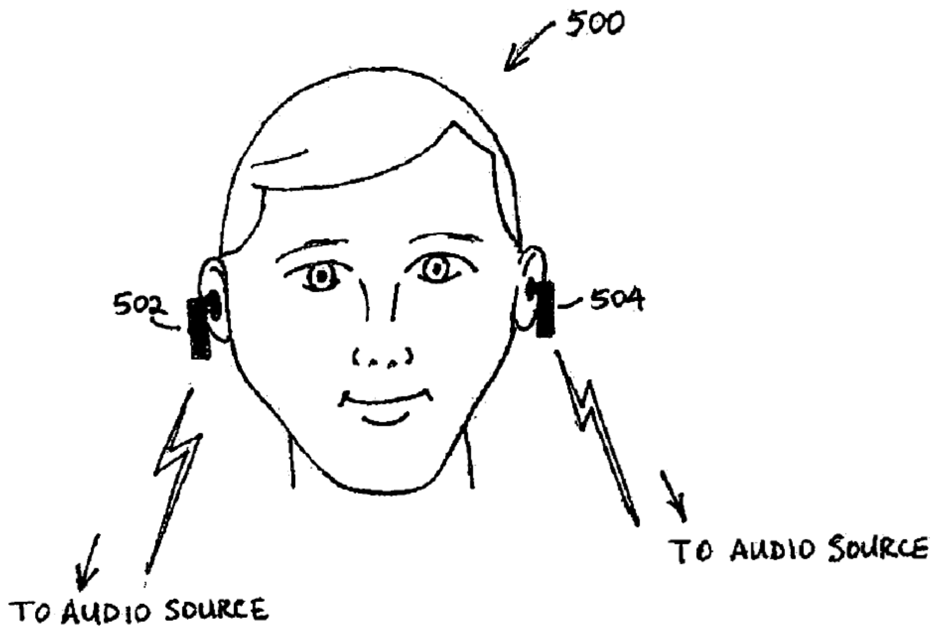
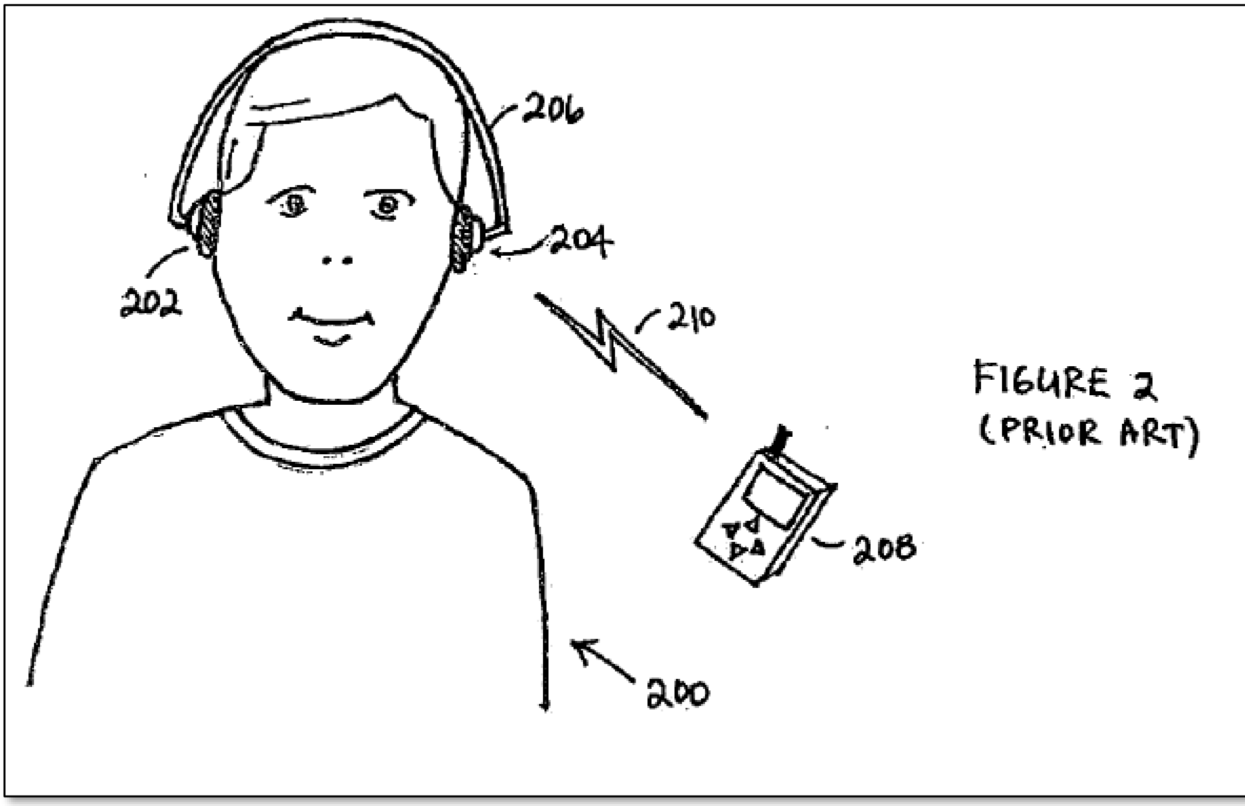


FIGURE 5

4. Headband-based and Connection-wire Design

66. By 2008, another common, well-known design element for a headphone assembly's form factor was a headband, which was typically attached to the two earphones in a stereo design (or to one earphone and an opposite side head pad in a monaural design). As Skulley corroborates, headband designs were (and are) most-commonly associated with on-the-ear and over-the-ear headphone form factors, *Skulley*, (Ex. 1017), 1:35-38.

67. A headband design for a stereo headphone is illustrated below from Rosener's Figure 2, which Rosener (circa 2006) expressly identifies as a prior art design:



68. By 2008, a POSA had reasons to offer a wireless headphone assembly in a form factor having a headband.

69. First, as noted in Paragraph 66 above, headbands were commonly associated with on-the-ear and over-the-ear designs, and thus a headband would have been a well-known means to implement an on-the-ear or over-the-ear design. Second, a headband was useful to provide structure for "forcefully maintaining the output face of the earphone in, against, or over the ear of the wearer." *Skulley* (Ex. 1017), 1:37-38. In-the-ear designs often used a different stability support

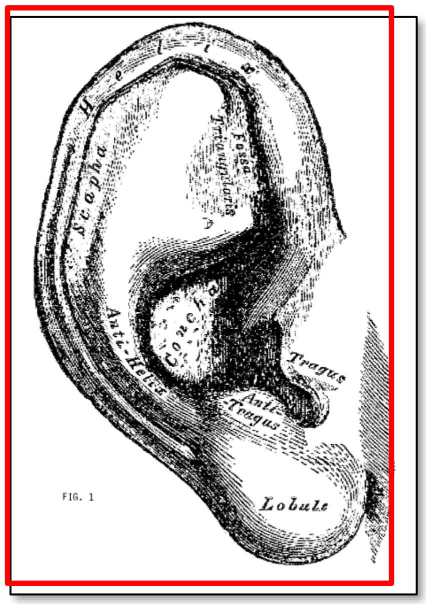
mechanism such as a hanger bar (or "arcuate earhook," as termed by Davis, Ex. 1033, 4:41 and Figure 1 (element 13), *see* Section VI.B.5 below), to help keep the in-the-ear earphone positioned within the user's ear. Third, headbands provided a way to hide and protect the wiring connecting the two earphones of the headphone assembly, where that wiring is typically used to bring the audio signal to each of the loudspeakers in the earphones. The headband can both carry and enclose the connection wire from one earphone to the other. This is corroborated by Rutschman (Ex. 1050) at [0007] which states as background information that in "dual-earpiece[] headsets, the earpieces are wired together and often integrated into a headband that secures an earpiece over or in each ear." (As I discuss below in Section VI.C, in a fully wireless design the connection wire is replaced by a wireless link.) Rutschman (Ex. 1050) at [0008] similarly notes that "known dual-earpiece headsets ***require*** additional wiring between earpieces." This is because, unless the headset is a fully wireless design (*see* Section VI.C below), the headphones typically used connection wiring located between the earphones. This is also corroborated by Huddart-2 (Ex. 1041) at [0002], which notes as background information that "[a] headband solution implements stereo operation by using the headband ***to carry the electrical signals*** from one side of the head to the other ***with an electrical wire***." A headband is often used to carry (and in some cases enclose) the wiring because exposed wiring is generally more susceptible to being broken or tangled. Similarly, if the headphone assembly had only one battery, the power supply line(s) to the battery was often connected by wire to each of the earphones to power any electrical components within the earphone, where this wire was often run through the headband to hide and shield it.

70. By 2008, a POSA would have understood that with ordinary skill wireless headphone assemblies in an on-the-ear, over-the-ear, and in-the-ear designs were implementable in a form-factor containing a headband. As noted above in Paragraph 66, and as Skulley confirms (Ex. 1017, 1:35-38), on-the-ear and over-the-ear designs in particular were commonly implemented with a headband that connected the two earphones in a stereo design.

5. Hanger-Bar Design

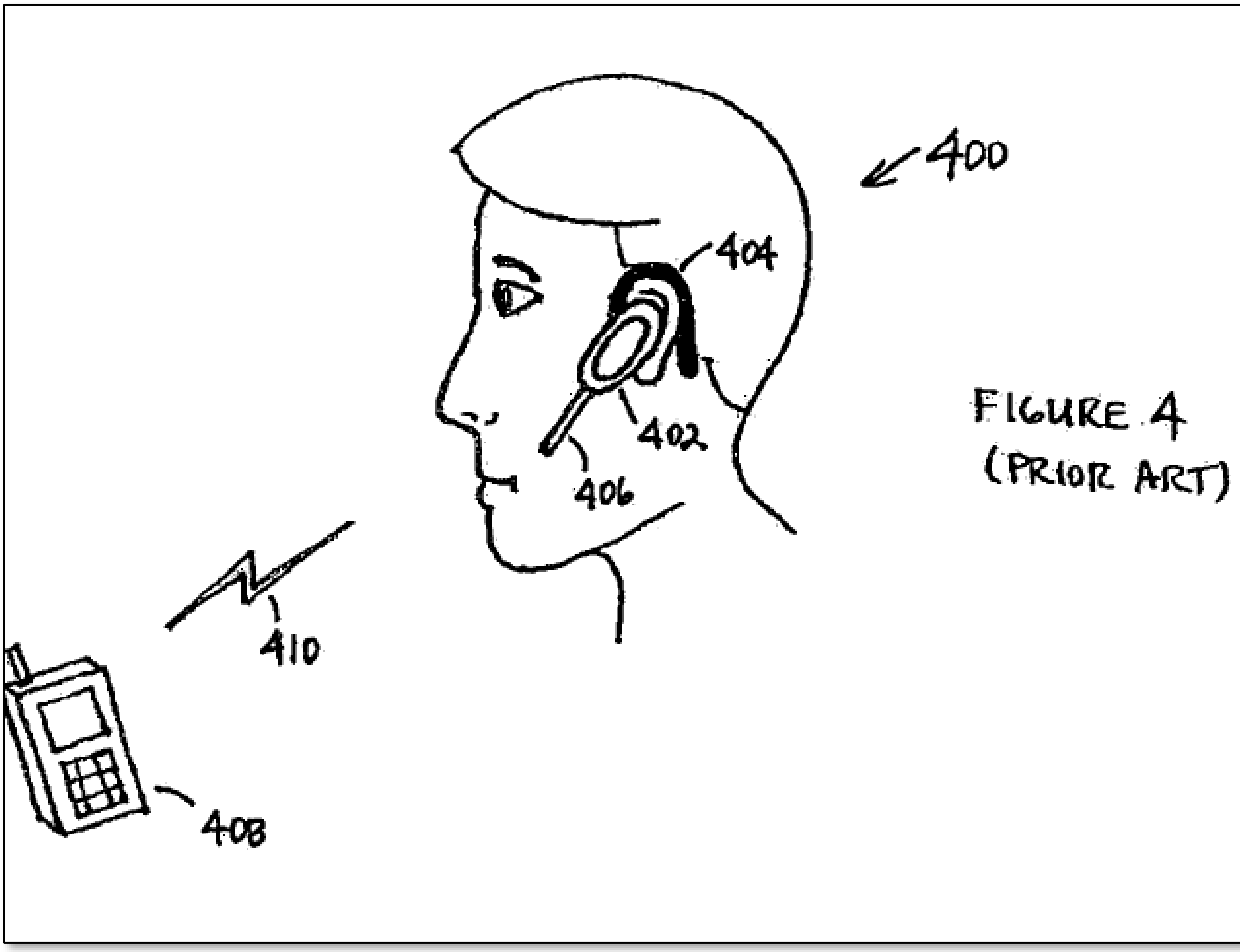
71. By 2008 another common, well-known stability support element for a headphone assembly's form factor was a hanger bar, sometimes called "earloop" (see *Rosener* (Ex. 1020), [0008]) or "earhook" (*see Davis* (Ex. 1033), 1:36-37; *MacDonald* (Ex. 1135), [0008]) resting over and/or around the pinna of a user's ear, which is the projecting part of the outer ear, as illustrated in the image below. Although the nomenclature is somewhat confusing, a hanger bar can also be referred to as an "over-the-ear" support system (see *Rosener* (Ex. 1020), [0008]) because it rests on the user's ear, not to be confused with the "over-the-ear" form factor that I discussed above in Section VI.B.2. Thus, when I refer to an "over-the-

ear" design I am referring to the form factor that I described above in Section VI.B.2, and not a hanger-bar design. A hanger bar was also sometimes referred to as a "behind-the-ear" design because often a portion of the hanger bar is behind the ear when against a user's ear, even though "behind-the-ear" also has been used to refer to an ear mold form factor.



Schanz (Ex. 1078), FIG. 1; *see also Goldstein* (Ex. 1026), [0043] ("behind the ear (BTE)"). (Goldstein is discussed further in Section IX.G below.)

72. Rosener's Figure 4 (copied below) illustrates an in-the-ear headphone design for one earphone having an "earloop 404" (a hanger bar) "that is configured to fit around the outer ear of the user 400." *Rosener* (Ex. 1020), [0008].



73. As illustrated in Rosener Figure 4 above and was well-known in hanger-bar design by 2008, the hanger bar is connected to a body (*e.g.*, headphone 402 in Figure 4) and the body typically contains an acoustic transducer (*e.g.*, the speaker within the body). The hanger bar (earloop 404) is generally shaped to fit around and sit on the upper curvature and behind the external ear (auricle) as illustrated in Rosener's Figure 4 above (*e.g.*, by being curved to generally conform to the upper curvature of the auricle, as illustrated in Rosener's Figure 4). A hanger-bar design was also often paired with an in-the-ear (intra-aural) earphone or

on-the-ear (supra-aural) earphone. When a hanger bar is paired with an in-the-ear design, at least a portion of the earphone's body typically extends at least partially into the concha or ear canal when worn by the user. In a configuration like that shown in Rosener's Figure 4 above, various elongated portions (such as an earloop or a voice tube for a microphone) extend from the earphone's body. *See Rosener* (Ex. 1020), [0008]. For example, Davis discloses "conventional self-supporting earhook headsets" that are flexible in adjustment by means of "a clamping mechanism to grip the user's ear" or a "dual point retention system using opposing leverage against the ear by portion of the earhook itself." *See Davis* (Ex. 1033), 1:43-47. The hanger bars were sometimes made to be adjustable to account for the fact that different individuals have different ear sizes and shapes. By making the hanger bar adjustable it could also improve the earphone's positioning on and comfort to the user. For example, U.S. Patent No. 6,097,809 ("Lucey") (Ex. 1127) discloses a headset with an "adjustable ear support," *i.e.,* a hanger bar, "to fit a variety of ear sizes without affecting the balance of the ear support on the ear of the wearer." Abstract; *see also* 1:52-59, 4:37-67, FIGS. 1, 5. Also, U.S. Patent Application No. 2002/0041697 ("MacDonald") (Ex. 1135) discloses "a flexible earhook," *i.e.*, a hanger bar, "for positioning an earphone adjacent a wearer's ear compris[ing] … a hook element comprising a material capable of being contoured and thereafter maintaining its shape." *See MacDonald* (Ex. 1135), [0008].

Furthermore, as illustrated in MacDonald's FIG. 1, "[t]he hook element 101 is flexibly adjustable, which allows a wearer to adjust it to conform comfortably to the shape of his or her ear" and a "curved portion 106 may be shaped to make fitting of the earhook 100 onto the wearer's ear comfortable." *See MacDonald* (Ex. 1135), [0022]-[0023], FIG. 1.

74. Rosener states that Figure 4 illustrates an example of a "Bluetooth enabled over-the-ear wireless headset" that "is known in the art as a 'monaural' headset, since it operates with only one of the user's two ears." *Rosener* (Ex. 1020), [0008]. A person of ordinary skill, however, knew that the form factor illustrated in Rosener's Figure 4 was compatible with a headphone assembly designed for both ears (*e.g.*, a stereo headphone assembly, *see* Section VI.A above). When implementing a form factor like that shown in Rosener's Figure 4 in a two-earphone assembly, each earphone would typically be connected by a wire (*see* Section VI.B.4 above) or implemented in a fully wireless design (*see* Section VI.C below). Each earphone would also typically look identical to each other or the external shape for each earphone would be configured to fit in a user's left or right ear. *See, e.g., Davis* (Ex. 1033), 1:33-36 (Davis is discussed further in Section IX.D below). Also, if a microphone was included (*e.g.*, the voice tube 406 in Rosener's Figure 4), it was known that the microphone only needed to be affixed to one of the earphone housings (*e.g.*, the left-ear earphone), though there

were also known benefits to having two microphones (*e.g.*, to facilitate stereo recording of the user's voice).

75. A POSA would have had several reasons to design a wireless headphone assembly to have a hanger bar. First, as Rosener explains, a POSA would have understood that a hanger-bar design is useful as a "securing mechanism to help maintain the earphone…on the ear of the user." *See Rosener* (Ex. 1020), [0030]. Moreover, for some users or situations, a hanger-bar design was better at keeping the earphone in a precise position, with respect to the user's ear compared to a headband design, particularly for alignment of the loudspeaker's output with the ear canal. As I noted above in Paragraph 73, to facilitate this alignment and improve user comfort, the hanger bar was often curved and adjustable. Second, some users preferred a hanger-bar-based design to a headband-based design because a headband often interfered with a user's hair, hats, or caps, whereas a hanger bar did not pose the same problem. Third, some users simply preferred the aesthetics of a hanger-bar design compared to other types of designs. Fourth, a hanger-bar-based design was one of a finite number of known configurations for a wireless headphone assembly.

76. By 2008, a POSA knew that it took only ordinary skill to implement a wireless headphone assembly in an in-the-ear or on the-ear (supra-aural) form factor to have a hanger bar. A POSA would have known that incorporating a

hanger bar with existing housing required little-to-no modifications to the rest of the housing because the hanger bar is generally complementary to the rest of the housing; that is, in general, a hanger bar can be added to an earphone without necessitating any other design changes to the earphone (and if any design changes were necessary to mount the hanger bar, they were typically minimal and only required ordinary skill to incorporate).

C. Fully Wireless Design

77. By 2008, another well-known design for a wireless headphone assembly was one in which the earphones in a stereo assembly were ***not*** connected by a wire or headband, which I will term a "fully wireless" or "true wireless" design. Rosener's Figure 5 (copied below) illustrates a fully wireless design with two earphones 502 and 504 (in the form of earbuds in this example):

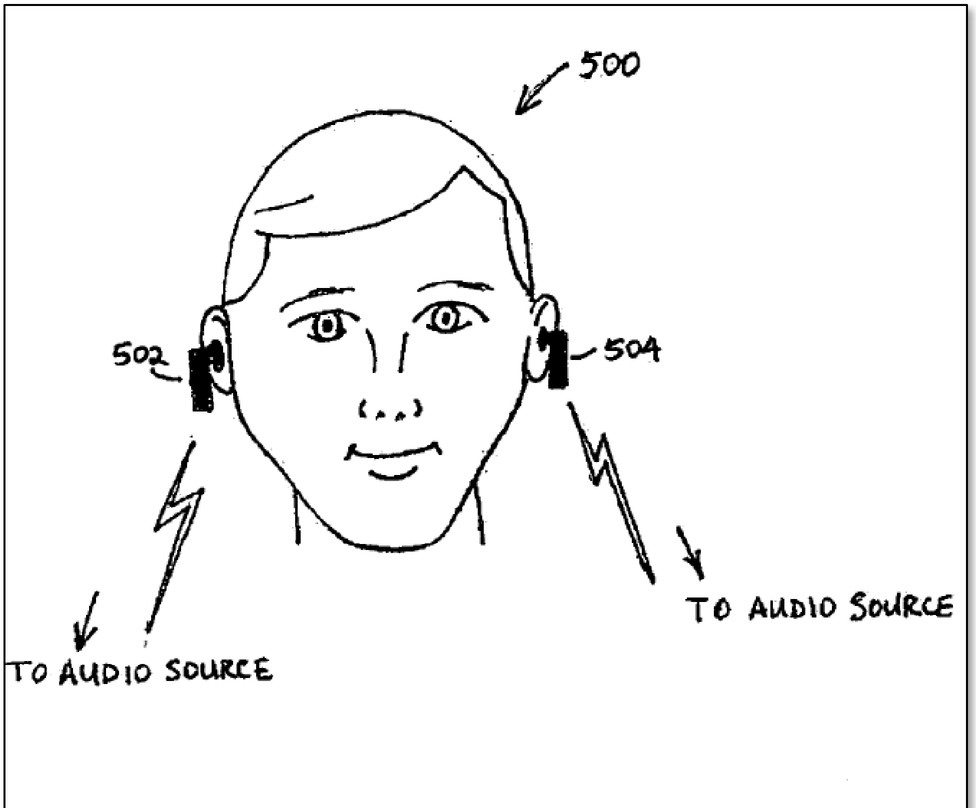


FIGURE 5

See Rosener (Ex. 1020), [0030], [0032].

78. A fully wireless design in the prior art is also illustrated by Huddart (Ex. 1024), which discloses a "wireless stereo headset" (*i.e.*, a wireless stereo headphone assembly) where "[b]oth the first headset component [*e.g.*, with a first earphone] and the second headset component [*e.g.*, with a second earphone] may be wireless devices." *See Huddart* (Ex. 1024), Abstract, FIGS. 3 (44 and 42) and 6 (204 and 202) (both copied below); *see also* Section IX.E below (discussing Oh's teachings for a fully wireless design).

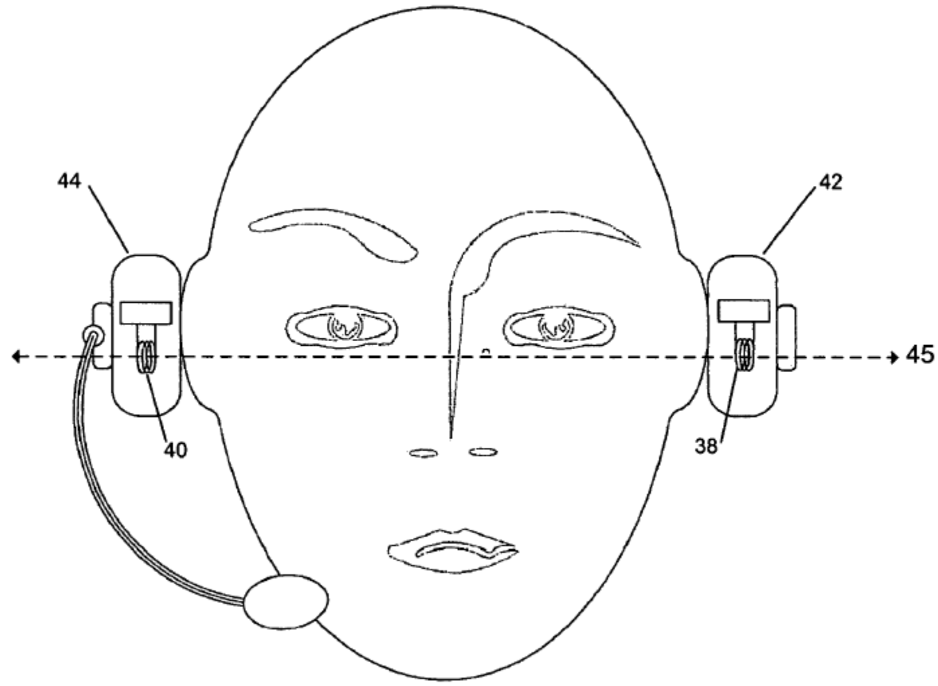


FIG. 3

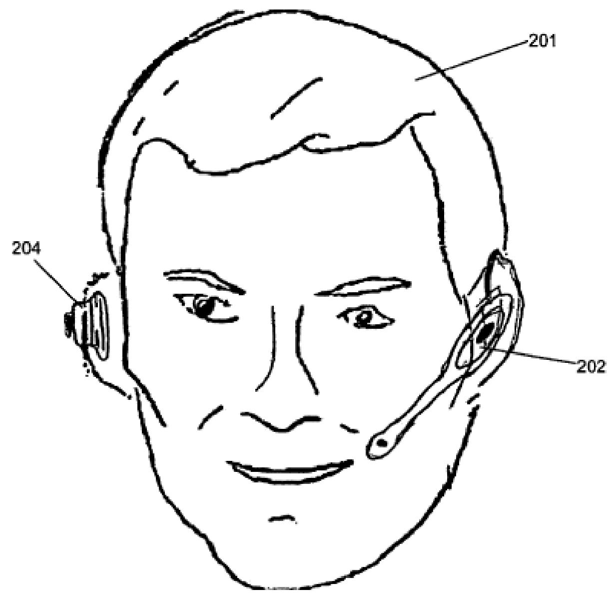


FIG. 6

79. By 2008, a POSA would have had several reasons to implement a stereo wireless headphone assembly in a fully wireless design. First, as Huddart-2 (Ex. 1041) at [0003] corroborates, it was known that "[t]he user may not wish to have any wires attached to any part of the headset or worn about the body." *See also Rutschman* (Ex. 1050), [0009] ("There is also a need for an improved headset that provides a dual-earpiece configuration that eliminates the need for headbands and wiring between earpieces, and is therefore better scaled to the relatively small size of many contemporary audio devices."). As Zellner (Ex. 1042) at 1:26-29

further corroborates, it was known that users "must sacrifice some of the benefits of being entirely wireless" when using "stereo earbuds…linked by a wired connection." This is in part because a wire connecting the two earphones can tangle and tug when a wearer moves his/her head, and loss of fit of the earbud can result. Similarly, a headband adds bulk to the headphone, making it harder to carry in one's pocket or purse compared to a fully wireless design. Second, many people preferred the look of a fully wireless design, because it eliminated wires or headbands connecting the two earphones. As Rosener corroborates, "[s]ome users find wearing a headband to be uncomfortable and/or disruptive to their headdress or coiffure." *Rosener* (Ex. 1020) [0006]. Third, as I noted above in Paragraphs 77-78 (citing *Rosener* (Ex. 1020) and *Huddart* (Ex. 1024); *see also* Exs. 1041-1042, 1050; Section IX.E below), a fully wireless design was a known configuration for a wireless headphone assembly by 2008 and thus implementing a headphone assembly in a fully wireless design would have been using a known technique to improve similar headphone devices in the same way.

80. By 2008, it would have required ordinary skill to implement a wireless headphone assembly in a fully wireless design. As demonstrated above in Paragraphs 77-79, the prior art had already provided multiple examples of fully wireless headphone assembly designs. *See, e.g.*, *Rosener* (Ex. 1020), FIG. 5; *Huddart*-2 (Ex. 1041), FIG. 3; *Zellner* (Ex. 1042), FIGS. 1-2, 3B. By 2008, a

product designer working in collaboration with a person experienced with wireless communications (*see* Section V above), would have used their ordinary skill to adapt the components used in an on-the-ear, over-the-ear, or in-the-ear headphone assembly to fit within a fully wireless design.

D. User-Controls

81. By 2008, headphone assemblies often had manual controls of various types that allowed the user to perform certain functions, such as activation of a microphone for providing voice requests to a WPM server, to activate music functions, to send commands, or to turn the earphone's electronics on or off. *See, e.g.*, *Rezvani-446* (Ex. 1097), [0055]-[0056], FIG. 4 (discussed in Section IX.B below); *Goldstein* (Ex. 1026), [0069]) (discussed in Section IX.G below).

82. Using a physical user-control mechanism (*e.g.*, a finger-operated rocker switch, slide switch or pushbutton) to turn on and off certain functions, was known to help minimize energy consumption and thus save battery power. Among other advantages, a physical "push-to-talk" microphone switch was also generally better than a voice-activated system for avoiding missed initial vocalizations, and for avoiding pick-up of unwanted ambient sounds when the user was not actually speaking. The use of a manual control with a click-through activation or "detent" feature also provided the advantage of giving the user positive tactile feedback when a microphone was activated or another function was accomplished. It was

also common by 2008 for the user-control of a microphone to be implemented using a voice-activated switch, whereby the person speaking would activate the microphone without the need for a manual control input. Thus, a voice-activated switch also had the advantage of freeing up the user's hands, which is particularly useful while driving or performing other activities that require the user's hands.

83. Similarly, a POSA would have known to include a control button on the headphone assembly so that the user could interact with other devices without having to physically contact (*i.e.*, touch) the other device (*e.g.*, pausing music playback, answering, or hanging up a phone call, or controlling sound level output). In certain instances, such headphone assembly-mounted control would offer ergonomics and usability advantages that accrue when the controlled device itself does not have to be controlled through its own integral manual controls.

VII. THE HEADPHONE ASSEMBLY DESIGNS DISCLOSED IN THE '025 PATENT

84. I have reviewed the '025 patent and its file history (Ex. 1002) and provide below a summary of the headphone assembly designs disclosed in the '025 patent.

85. As I discuss below in this section, each of the form factors disclosed in the '025 patent rely on conventional headphone assembly designs that were well-known in the prior art that I discussed in Section VI above. The '025 patent also describes wireless communication aspects of a wireless headphone assembly

design. Though I have read those sections and considered them in my opinions to the extent they would have been considered by an engineer or product designer collaborating with a person having a background in wireless communications (*see* Section V above), I have not been asked to opine on the wireless communication aspects of the wireless headphone assemblies discussed in the ’025 patent.

86. The ’025 patent notes as background information that headphones for use with digital audio players (*e.g.*, “MP3 players and iPods”) are often “in-ear type headphones.” ’025 patent, 1:41, 1:46-47. The ’025 patent further states as background information that “cordless headphones that connect wirelessly…have been proposed” but “are also quite large and not in-ear type phones.” ’025 patent, 1:57-61. As cited above, the ’025 patent’s background states that cordless (*i.e.*, wireless) headphones of the in-the-ear type (*e.g.*, earbuds) were known in the prior art, and as I discussed above in Sections VI.B.3, cordless (*i.e.*, wireless) headphones in all three of the well-known form factors (on-the-ear, over-the-ear, and in-the-ear) were also known by 2008. The engineering effort in converting from an in-the-ear form factor to either an on-the-ear or over-the-ear form factor is less than going from an on-the-ear or over-the-ear to an in-the-ear from factor, from a packaging standpoint. In the first direction of development the challenges of size with respect to all functional components have been overcome when starting with an in-the-ear form, and moving to a form factor with more design

space (*e.g.*, on-the-ear or over-the-ear) is easier. By at least 2008, it was also well-known, and required only ordinary skill, to go from an over-the-ear or on-the-ear design to an in-ear design because "off-the-shelf" components used in an in-the-ear headphone assembly had been significantly miniaturized by then. In any event, as I discussed above in Sections VI.B.1-VI.B.3, a POSA had reason to implement wireless headphone assemblies in each of the three form factors, with an expectation of success using ordinary skill, at least because the form factors themselves were well-known by 2008 and each was compatible with a wireless design.

87. The '025 patent states that its earphone 10 can be incorporated into each of the three form factors that I described above in Sections VI.B.1-VI.B.3: in-the-ear (ear bud), on-the-ear, and over-the-ear designs. The '025 patent discloses "[t]wo exemplary in-ear earphone shapes for the wireless earphone 10…in FIGS. 1A and 1B [copied below], respectively, although in other embodiments the earphone may take different shapes…." '025 patent, 2:59-62. For example, FIG. 1C (copied below) illustrates an embodiment where "a headband 19 may connect the two (left and right) earphones 10." '025 patent, 3:51-52. The '025 patent also states (but does not illustrate in a figure) that an embodiment can comprise "over-ear earphones." '025 patent, 3:63-65.

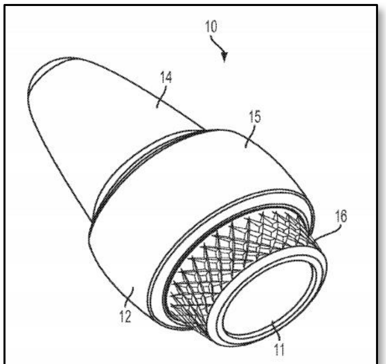


FIG. 1A

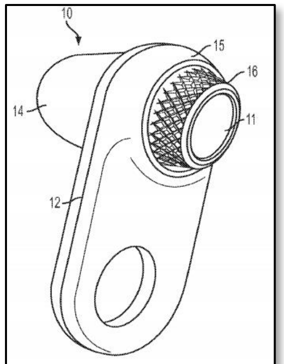


FIG. 1B

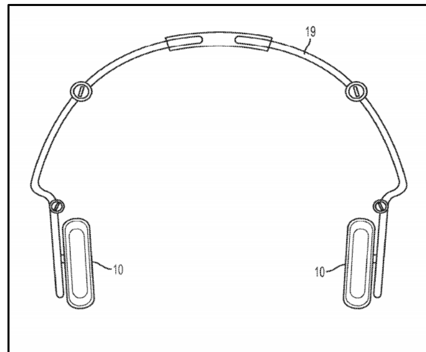


FIG. 1C

88. I note that the ’025 patent does not allege to have invented any of these form factors, which were well-known and common in the prior art, as I discussed above in Sections VI.B.1-VI.B.3. I further note that while the ’025 patent mentions the selection and housing of components in various ways depending upon embodiment chosen (*e.g.*, ’025 patent, 6:33-51), that there is minimal detail about specific means of implementation of earphone 10 in each of the three form factors. This is consistent with my opinions discussed in Sections VI.B.1-VI.B.3 above, that by 2008, it would have required only ordinary skill to incorporate the functional components of a wireless headphone assembly into each of these form factors.

89. The ’025 patent further discloses that “earphone 10 may comprise a hanger bar 17 that allows the earphone 10 to clip to, or hang on, the user’s ear, as shown in the illustrated embodiment of FIGS. 1D-1E” (’025 patent, 3:66-67, 4:1-17), which I have copied below:

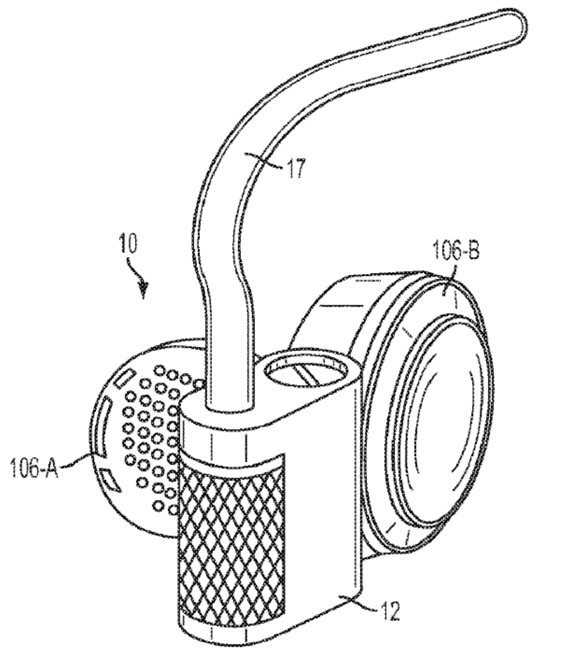


FIG. 1D

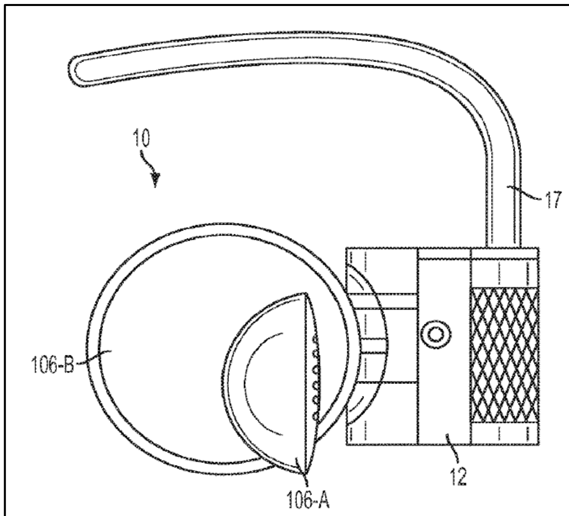


FIG. 1E

90. The design shown in FIGS. 1D-1E has two speaker elements: 106-A and 106-B. The speaker element 106-A "is sized to fit into the cavum concha [*see* Section VI.B above discussing the concha] of the listener's ear and the other element (the larger one) 106-B is not." '025 patent, 4:6-8. As illustrated in the figures above, hanger bar 17 is connected to the body 12, which is connected to the speaker elements. Except for having two speaker elements on each earphone (which was also known as being primarily beneficial for higher fidelity playback), the hanger bar form factor illustrated in FIGS. 1D-1E is consistent with conventional hanger-bar designs known in the prior art, as discussed above in Section VI.B.5.

91. Figure 9, copied below, illustrates the form factor for another embodiment, where the earphones 10 are connected to a headband and include “a microphone 104.” ’025 patent, 12:64-65. The ’025 patent states that a user “could activate the microphone by pressing a button 92 on the headset 90.” ’025 patent, 13:4-5.

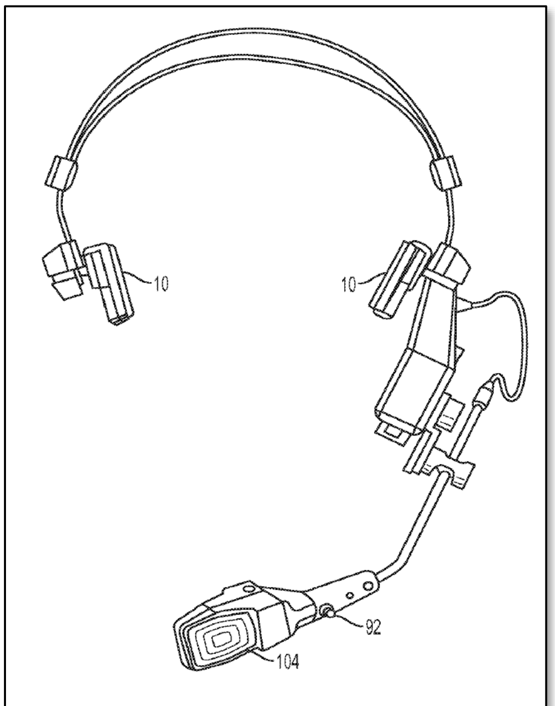


FIG. 9

92. As with the other form factors discussed above, the form factor illustrated in Figure 9 is consistent with a well-known, prior art headphone design of the on-the-ear form factor and having a microphone and control button, as discussed in Section VI.D above.

93. The ’025 patent explains that in some embodiments a user “may wear two discrete wireless earphones 10,” such as the “in-ear” earphones depicted in

Figures 1A and 1B, with the earphones located "one in each ear." '025 patent, 3:11-13, 3:45-46. In a two-earphone embodiment, the earphones may be "connected by a string or other cord-type connector to keep the earphones 10 from being separated." '025 patent, 3:46-50.

94. If no wiring at all is running between two earphones in the same "headphone assembly," a POSA would have understood the assembly to be a completely wireless (commonly known as true wireless) design. As I discussed above in Section VI.C, true wireless designs were conventional by April 2008.

VIII. THE HEADPHONE ASSEMBLY DESIGNS CLAIMED BY THE '025 PATENT

95. I have reviewed the challenged claims (1-56) of the '025 patent and have been asked to offer opinions relating to claims 1, 3, 6, 11, 13, 16, 20, 22, 25, 29, 31, 34, 39, 40, 43, 46, 53, 54, 55, and 56. As I discuss below in this section, claim 1 and several dependent claims (3, 6, 11, 13, 16, 20, 22, 25, 29, 31, 34, 39, 40, 43, 46, 53, 54, 55, and 56) recite limitations reading on one or more of the well-known headphone designs that I discussed above in Section VI. The other challenged claims generally add limitations regarding wireless functionality, which I have not been asked to opine on.

A. Claim 1

96. Claim 1, the only independent claim, is reproduced below with claim elements labeled [1A]-[1F] for ease of reference.

[1A] A system comprising:

[1B] a mobile, digital audio player that stores digital audio content; and

[1C] a headphone assembly, separate from and in wireless communication with the mobile digital audio player, wherein the headphone assembly comprises:

> **[1C1]** first and second earphones, wherein each of the first and second earphones comprises an acoustic transducer;
>
> **[1C2]** an antenna for receiving wireless signals from the mobile, digital audio player via one or more ad hoc wireless communication links;
>
> **[1C3]** a wireless communication circuit connected to the at least one antenna, wherein the at least one wireless communication circuit is for receiving and transmitting wireless signals to and from the headphone assembly;
>
> **[1C4]** a processor;
>
> **[1C5]** a rechargeable battery for powering the headphone assembly; and
>
> **[1C6]** a microphone for picking up utterances by a user of the headphone assembly; and

[1D] a remote, network-connected server that is in wireless communication with the mobile, digital audio player;

[1E] wherein the mobile, digital audio player is for transmitting digital audio content to the headphone assembly via the one or more ad hoc wireless communication links, such that the digital audio content received by the headphone assembly from the mobile, digital audio player is playable by the first and second earphones; and

[1F] wherein the processor is for, upon activation of a user-control of the headphone assembly, initiating transmission of a request to the remote, network-connected server.

97. With respect to the form-factor of the headphone assembly of claim 1, limitation [1C1] requires the headphone assembly to have "first and second earphones, wherein each of the first and second earphones comprises an acoustic transducer." Consistent with a POSA's understanding, the '025 patent discloses that an example of an acoustic transducer is a speaker. *See* '025 patent, 6:31-32 ("one or more acoustic transducers 106 (*e.g.*, speakers)"). Thus limitation [1C1] is consistent with a conventional two-earphone / two-speaker form factor that I discussed in Section VI.A above, which, as I explained in that section, is exemplified by a stereo headphone design for particular applications, especially music playback, although monaural embodiments also were known to be common using a two-earphone / two-speaker design. Additionally, limitation [1C6] requires the headphone assembly to have "a microphone for picking up utterances by a user of the headphone assembly." This limitation [1C6] is consistent with a conventional microphone serving to receive user speech and input that I discussed in Section VI.A above.

98. The dependent claims (3, 6, 11, 13, 16, 20, 22, 25, 29, 31, 34, 39, 40, 43, 46, 53, 54, 55, and 56) discussed in Sections VIII.B-VIII.I below recite

additional conventional features of a wireless headphone assembly (such as configuring the headphone assembly's earphones in an "earbud," "on-ear," or "over-ear" design).

B. Claims 3, 6, 13, 16, 22, 25, 31, 34, 43, and 46

99. **Claim 3** recites "The system of claim 2, wherein the processor of the headphone is further for: processing audible utterances by the user picked up by the microphone in response to activation of the microphone by the user; and transmitting a communication based on the audible utterances via the one or more ad hoc wireless communication links."

100. **Claim 6** depends on claim 1, and adds the same limitations to claim 1 that claim 3 adds to claim 2.

101. **Claim 13** depends on claim 12, and add the same limitations to claim 12 that claim 3 adds to claim 2.

102. **Claim 16** depends on claim 11, and add the same limitations to claim 11 that claim 3 adds to claim 2.

103. **Claim 22** depends on claim 21, and add the same limitations to claim 21 that claim 3 adds to claim 2.

104. **Claim 25** depends on claim 20, and add the same limitations to claim 20 that claim 3 adds to claim 2.

105. **Claim 31** depends on claim 30, and add the same limitations to claim 30 that claim 3 adds to claim 2.

106. **Claim 34** depends on claim 29, and add the same limitations to claim 29 that claim 3 adds to claim 2.

107. **Claim 43** depends on claim 42, and add the same limitations to claim 42 that claim 3 adds to claim 2.

108. **Claim 46** depends on claim 41, and add the same limitations to claim 41 that claim 3 adds to claim 2.

109. As I discussed in Section VI.D above, by 2008 it was well-known for a headphone assembly to include a user-control and/or a microphone to implement various functionalities, one user-control function comprising activation of the microphone (or turning the entire earphone itself on or off), for the reasons I discussed in that section.

C. Claim 11

110. Claim 11 recites "The system of claim 1, wherein: [11A] the wireless communication circuit is located in the first earphone; and [11B] the headphone assembly further comprises a connection wire between the first and second earphones to carry the received digital audio content from the first earphone to the second earphone."

111. As I discussed in Section VI.B.4 above, by 2008 it was well-known for a headphone assembly to include a connection wire from one earphone to the other. As I also discussed above in Sections VI.B.1-VI.B.3, it was well-known by 2008 to locate the electrical components of the headphone in one of the earphone's housings.

D. Claim 20

112. Claim 20 recites "The system of claim 11, wherein the headphone assembly further comprises a headband, and wherein the headband carries the connection wire."

113. As I discussed above in Section VI.B.4, a POSA by 2008 had several reasons to implement a wireless headphone assembly with a headband carrying a connection wire for the reasons I discussed in that section.

E. Claims 29 and 53

114. **Claim 29** recites "The system of claim 11, wherein each of the first and second earphones comprises: an adjustable, curved hanger bar that sits upon an upper external curvature of a user's ear, behind the an upper portion of an auricula of the user's ear, when the headphone assembly is worn by the user; and a body connected to the hanger bar, wherein the earphone extends from the body into the user's ear when the headphone assembly is worn by the user."

115. **Claim 53** depends from claim 1, and adds the same limitations to claim 1 that claim 29 adds to claim 11.

116. As I discussed above in Section VI.B.5, it was conventional by 2008 for a POSA to implement a headphone assembly in a form factor having a hanger bar that rests upon an upper external curvature of a user's external ear (*i.e.*, the auricle or pinna), for the reasons I discussed in that section, and that in these hanger-bar designs it was also common for the hanger bar to be connected to a body, and for the earphone to extend from the body (at least partially) into the user's ear during use. As I discussed above in Section VI.B.5, it was also common by 2008 for the earhook in a hanger-bar design to be adjustable and curved to properly sit on the external curvature of the user's ear, and in some designs behind an upper portion of an auricula of the user's ear, for the reasons I discussed in that section.

F. Claims 39 and 54

117. **Claim 39** recites "The system of claim 11, wherein each of the first and second earphones comprise earbuds."

118. **Claim 54** depends from claim 1, and adds the same limitation to claim 1 that claim 39 adds to claim 11.

119. As I discussed in Section VI.B.3, by 2008 a POSA would have had several reasons to implement a headphone assembly using an earbud form factor, for the reasons I discussed in that section.

G. Claim 40

120. Claim 40 recites "[40A] The system of claim 1, wherein each of the first and second earphones comprises: at least one acoustic transducer; [40B] a wireless communication circuit; [40C] a body portion that sits at least partially in an ear of the user when the headphone assembly is worn by the user; and [40D] an elongated portion that extends from the body portion."

121. Though claim 40 does not recite whether or not a wire or headband connects the two earphones in the wireless headphone assembly of claim 40, a POSA would have understood that claim 40 reads on the fully wireless embodiment illustrated in the '025 patent's Figure 10, which I discussed above in Section VII. As I discussed above in Section VI.C, by 2008, fully wireless headphone assemblies were known in the prior art, with known benefits that I discussed in that section. Furthermore, as I discussed above in Section VI.B.3, by 2008 it was well-known to implement a pair of earphones where each earphone comprised a body portion that sat at least partially in an ear of the user (*e.g.*, earbuds) and an elongated portion that extended from the body portion (*e.g.*, an earloop and/or a microphone tube).

H. Claim 55

122. Claim 55 recites "The system of claim 1, wherein each of the first and second earphones comprise on-ear speaker elements."

123. As I discussed above in Section VI.B.1 above, by 2008 it was well-known to implement a pair of earphones comprised of speaker elements, wherein each earphone of the pair is designed to have an on-ear speaker element, for the reasons I discussed in that section.

I. Claim 56

124. Claim 56 recites "The system of claim 1, wherein each of the first and second earphones comprise over-ear speaker elements."

125. As I discussed above in Section VI.B.2, by 2008 it was well-known to implement a pair of earphones comprising speaker elements, where each earphone of the pair is designed to be over-ear speaker elements, for the reasons I discussed in that section.

IX. THE HEADPHONE ASSEMBLY DESIGNS DISCLOSED IN THE PRIOR ART

126. In this section I address whether certain limitations of the challenged claims were disclosed in, taught, or motivated by the teachings of the prior art references that I discuss in this section. I understand that Bose's Petition argues that these references in various combinations identified in the Petition would have rendered obvious the challenged claims of the '025 patent. I have reviewed these

references and considered them in my opinions to the extent they would have been considered by an engineer or product designer collaborating with a POSA having a background in wireless communications (*see* Section V above), though I have not been asked to opine on the wireless communication aspects of the wireless headphone assemblies discussed in any of these references or the obviousness of any claim as a whole.

A. Rezvani-875 (Ex. 1016): U.S. Patent Application Publication No. 2007/0165875

127. According to the face of the document, Rezvani-875 is a U.S. published patent application filed on December 1, 2006 (22), and published on July 19, 2007 (45), titled “High Fidelity Multimedia Wireless Headset.”

128. Rezvani-875 discloses a “wireless multi-media headset with high fidelity sound.” *Rezvani-875* (Ex. 1016), Abstract (57), [0015]-[0016]; FIG. 1. As illustrated in FIG. 2 (copied below), the headset includes an audio interface 227 [sic: ‘226’], which comprises a microphone array 227 and “input 228 and an output 229.” *Rezvani-875* (Ex. 1016), [0020]. A POSA would have understood that output 229 is produced by an acoustic transducer because such transducer is essential for providing an audible acoustic signal to the ears, and also this is corroborated by the symbol shown in Rezvani-875 FIG. 2 and labeled 229, which is the standardized symbol for a speaker (which is indeed an acoustic transducer),

as specified by IEEE Standard (Ex. 1027) 315-1975 (Reaffirmed in 1993) for Graphic Symbols for Electrical and Electronics Diagrams at 10.1.3.1, p. 141.

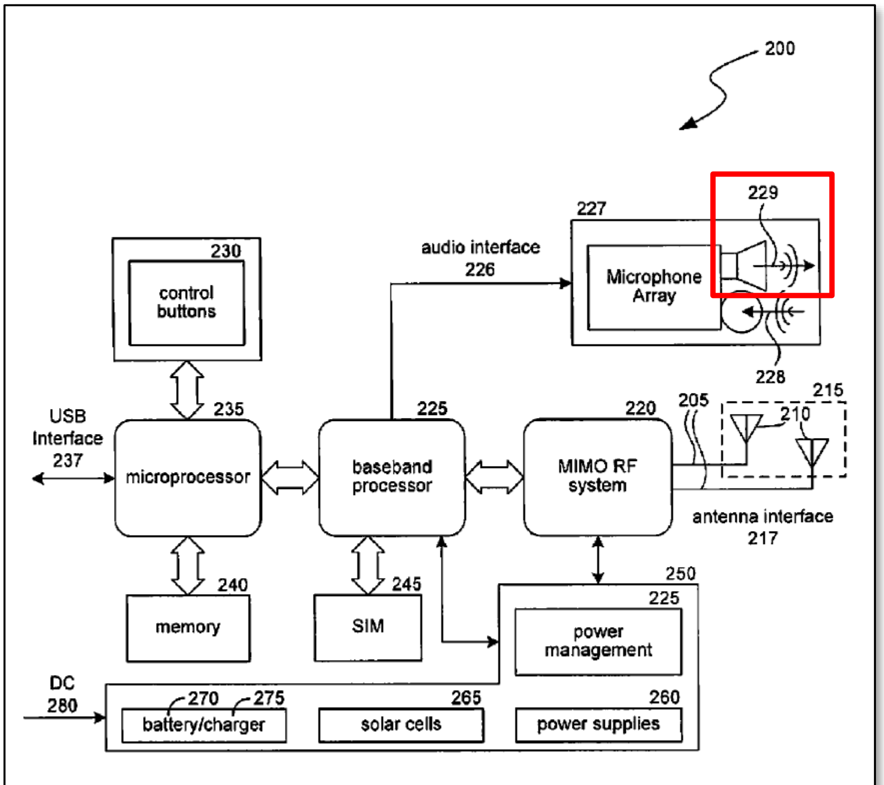


FIG. 2

129. Rezvani-875 does not explicitly state whether its headphone assembly has one or two output elements 229. However, Rezvani-875 is directed to “a High-Fidelity Multimedia Wireless Headset” for providing “a high fidelity sound system” for use with applications like VoIP calling and playback of music. *Rezvani-875* (Ex. 1016), [0015], [0024], [0039], [0041]. High-fidelity sound reproduction (often abbreviated as “Hi-Fi”) generally refers to reproducing sound (typically music) with very high quality and accuracy. Though Hi-Fi is not

necessarily synonymous with stereo sound systems, the two terms are often used synonymously: most humans hear sound in stereo, using both ears, so the highest fidelity reproduction of sound for humans requires at least two speakers, one for each ear. For that reason, Rezvani-875's teaching of a high-fidelity headphone assembly would have at least motivated a person of ordinary skill in the art to implement Rezvani-875 in a stereo design in any of the well-known form factors (*i.e.*, on-the-ear, in-the-ear, and over-the-ear, and with or without a headband as applicable) as taught by, for example, Skulley (*see* Section IX.C below) and/or with a curved hanger bar (as applicable) as taught by, for example, Davis with an "arcuate earhook" (*see* Section IX.D below; Ex. 1033, 4:42) and/or with an adjustable hanger bar as taught by, for example, MacDonald (Ex. 1135), [0008] with "a flexible earhook" (*see* Section VI.B.5 above; Ex. 1135, [0008]) and/or in a fully wireless design, as taught by, for example, Oh (*see* Section IX.E below), for the benefits I discussed in Sections VI.A-VI.C above. This is corroborated, for example, by Liu (Ex. 1023), [0005] ("Stereo headsets are mostly used when users wish to listen to music as they have two earphones for creating stereo sound.") and Huddart (Ex. 1024), 1:8-12 ("[T]here are certain usage scenarios in which the user of a wireless communication headset may wish to listen to a stereo signal using both ears. Such usage scenarios are expected to increase with the availability of a variety of electronic device and multi-function devices.").

130. As I discussed in Section VI.B above, different users have different preferences in sound quality, sound attenuation, aesthetics, weight, ease of fitting and comfort associated with each form factor, which would have also motivated a POSA to implement Rezvani-875's headphone assembly in each of the form factors that I discussed in Section VI.B above.

131. For example, as I discussed above in Section VI.B.2, over-the-ear designs provided passive sound attenuation and often connected the earphones with a headband for the benefits a headband provides (Section VI.B.4 above). As I discussed above in Section VI.B.1, on-the-ear designs were typically lighter than over-the-ear designs, were considered more comfortable by some users, and also typically incorporated a headband. A POSA would have understood that the headband in either an on-the-ear or over-the-ear design would have been beneficial to several applications. Examples would be when riding an off-road vehicle or operating a riding mower, because a headband (or a hanger bar) would provide some stability in helping to maintain the earphones in position on the head in the face of the jostling caused by the ridden vehicle or mower. Thus, a POSA would have understood that implementing Rezvani-875's headset in an on-the-ear design and/or over-the-ear design, such as described in Skulley (*see* Section IX.C above), would have had known benefits to users in a variety of situations.

132. Similarly, in Section VI.B.3 above, I explained that in-the-ear (earbud) designs generally provided improved sound delivery and noise reduction and they generally had small form factors and so were generally lighter, smaller, and less obtrusive than on-the-ear and over-the-ear designs. As I discussed in Section VI.B.3 above, in-the-ear designs were often made to be carried in a user's pocket and fit snugly into the concha and/or well into the user's ear canal to provide improved sound delivery (*i.e.*, reduce the loss of sound reaching the user's tympanic membrane) and noise reduction. Thus, a POSA would have understood that implementing Rezvani-875's headset in an in-the-ear design, such as taught by Davis (Section IX.D above) and Skulley (Section IX.C above), would have had benefits to a user in a variety of situations.

133. As I discussed in Section VI.B.5 above, by 2008 another common form factor for a headphone assembly was one that included an adjustable, curved hanger bar that is curved to fit around and sit on an upper external curvature of a user's ear, and in some designs also behind the upper portion of the external ear (auricle), when the headphone assembly is worn by the user. As I discuss below in Section IX.D, for example, Davis discloses an earphone design with a curved hanger bar (*i.e.*, "arcuate earhook") that sits upon an upper external curvature of a user's user, which Davis uses with an in-the-ear earphone design. *See* Davis, 4:42; *see also* Section IX.D below (discussing Davis's FIGS. 1, 8). As I discussed above

in Section VI.B.5 and below in Section IX.D, adjustable hanger-bar designs had known benefits (*e.g.*, the hanger bar kept the earphone in a fixed position at the ear, and by being adjustable, the hanger bar could be made to fit a variety of ear and head shapes). Thus, a POSA understood there would have been benefits to implementing Rezvani-875's headphone assembly in an adjustable hanger-bar design, as taught by Davis (*see, e.g.*, *Davis* (Ex. 1033) 4:42, FIGS. 1 and 8 Section IX.D below) using an in-the-ear form factor, as taught by Davis (*see, e.g.*, *Davis* (Ex. 1033), FIGS. 1 and 8 Section IX.D below) and Skulley (*see, e.g.*, *Skulley* (Ex. 1017), 1:24-25 and Section IX.C below).

134. As I discussed above in Section VI.B.5, to achieve stereo sound in a headphone assembly like Rezvani-875's, the earphones were often connected by a connection wire (often carried by a headband) to bring the stereo signal to each earphone, as corroborated by Rutschman (Ex. 1050) at [0007]-[0008] and Huddart-2 (Ex. 1041), [0002]. A POSA understood there would have been benefits to implementing Rezvani-875's assembly with a connection wire (*e.g.*, to achieve stereo sound) and carrying that connection wire in a headband (*e.g.*, to protect the connection wire when traveling, walking, or hiking, etc.), as was well-known in the art (Section VI.B.4 above).

135. As I discussed above in Section VI.C, it was also known by 2008 to implement headphone assemblies in fully wireless designs (*i.e.*, without a

connection wire between earphones), such as taught by Oh (Ex. 1099, *see* Section IX.E below) and Rosener (Ex. 1020, *see* Section VI.C above), for the benefits that I discussed above in Section VI.C. For example, a POSA understood that a true-wireless design would have been beneficial to a user of Rezvani-875's headset to avoid tangling the wire and avoid the weight and rigidity of a headband.

136. As I discussed above in Section VI.A, stereo headphones were known and common in the art by 2008, which is corroborated, for example, by Skulley (1:22-34). Thus, implementing Rezvani-875 with two earphones would have been applying a known technique to improve similar devices in the same way (*i.e.*, to produce two-earphone stereo [or even two-earphone monaural] presentation of sound). *See also Liu* (Ex. 1023), [0004]-[0005]; *Huddart* (Ex. 1024), 1:7-15. Similarly, as I discussed above in Sections VI.B-VI.C, each of the above form-factors for a two-earphone headphone assembly were known and common in the art by 2008. Thus, implementing Rezvani-875's headset in any of these form factors would have been applying a known technique to improve similar devices in the same way (*i.e.*, to provide a headphone assembly in each of these well-known form factors).

137. A POSA would have also found implementing Rezvani-875 as stereo earphones obvious to try because, as I discussed above in Section VI.A and Skulley corroborates, stereo designs were one of a finite number of predictable

configurations for a headphone assembly between (1) monaural (which can comprise a one- or two-earphone design) and (2) stereo (which requires two earphones in its design). *See also Liu* (Ex. 1023), [0004] ("There are two types of commercial headsets available, namely mono headsets and stereo headsets."). A POSA would have also found implementing Rezvani-875's headset in each of the above form-factors obvious to try because, as I discussed above in Sections VI.B-VI.C, each was one of a finite number of predictable configurations for a headphone assembly.

138. In my opinion, a POSA would have only required ordinary skill to implement Rezvani-875's headset with two earphones and two speakers in any of the well-known form factors (*i.e.*, on-the-ear, in-the-ear, and over-the-ear, and with or without a headband as applicable) as taught by, for example, Skulley (*see* Section IX.C below) and/or with a curved hanger bar (as applicable) as taught by, for example, Davis (*see* Section IX.D below; Davis, 4:42) and/or in a fully wireless design, as taught by, for example, Oh (*see* Section IX.E below) because, as I demonstrated above in Sections VI.A-VI.C each was a well-known, conventional configuration for a headphone by the mid-2000s.

139. Rezvani-875 discloses that the headphone assembly can include a "control button" on the headphone assembly allowing a user to activate functionality "to initiate a search" request that a search-engine scan "a library (or

other database, source, or storage) for files or content matching the search terms" (*e.g.*, a "music file"). *Rezvani-875* (Ex. 1016), [0035]-[0036]. Thus, Rezvani-875's "control button" is an example of a user control for a headphone assembly. Rezvani-875 also discloses "[t]he microphone array 405 is coupled with a noise cancellation algorithm to pick up sound." *Rezvani-875* (Ex. 1016), [0026]. Rezvani-875 similarly discloses that the "speech, sound, or utterance[s]" by a user of the headphone assembly are "picked up the microphone array 515…." *Rezvani-875* (Ex. 1016), [0028]. Additionally, Rezvani-875 discloses voice recognition functionality. *Rezvani-875* (Ex. 1016), [0018]-[0020]. As I discussed in Section VI.D above, by 2008 it was well-known for a microphone in a headphone assembly to be activated by a user control, either via a control button like Rezvani-875's or with a voice-activated switch. Thus, to the extent Rezvani-875's microphone is not activated by the user speaking into the microphone, a POSA had reasons to configure Rezvani-875's microphone to be activated by a user control button, for the reasons I discussed above in Section VI.D.

B. Rezvani-446 (Ex. 1097): U.S. Patent Application Publication No. 2007/0136446

140. According to the face of the document, Rezvani-446 is a U.S. published patent application filed on December 1, 2006, and published on June 14, 2007, titled "Wireless Media Server System and Method." Rezvani-446 discloses using a wireless headset to access media on a wireless portable media (WPM)

server. *See Rezvani-446* (Ex. 1097), [0022], FIGS. 4-5, 7. The exemplary headset as discussed by Rezvani-446 may include a microphone to supply voice requests to the WPM server, other control "input mechanisms" such as "buttons or dials" to "generate a request," and voice-activated command mechanisms. *See Rezvani-446* (Ex. 1097), [0055]-[0056], FIG. 4.

C. Skulley (Ex. 1017): U.S. Patent No. 6,856,690

141. According to the face of the document, Skulley is a U.S. patent filed on January 9, 2002 (22), and issued on February 15, 2005 (45), titled "Comfortable Earphone Cushions." As I discussed in Section VI.A above, Skulley's Background teaches that it was well-known by Skulley's filing in 2002 (and thus by 2008) for headphone assemblies to have "one or two earphones for monaural or stereo listening." *See Skulley* (Ex. 1017), 1:22-23. In Section VI.A above, I also discussed the use cases where a POSA would have wanted to offer a headphone assembly in each of these designs. For example, a one-earphone design was sometimes preferred for a call-center operator so they could listen to customers on the phone through the earphone while also being able to hear nearby co-workers and ambient signals with their unoccluded ear. On the other hand, stereo headphone designs, with two earphones and a minimum of one speaker in each earphone, were typically preferred by users who wanted to listen to high-quality

stereo music and in some scenarios to attenuate ambient noise when listening to the playback content.

142. As I also discussed above in Section VI.B.1-VI.B.3, Skulley further corroborates my opinion that by 2008 both monaural and stereo headphone designs "can be classified into three general types in accordance with the type of earphone they employ: 1) 'In-the-ear' type earphones, sometimes referred to as 'ear buds,' which fit into the concha, or entrance to a wearer's middle [correction: see footnote #7 above] ear;" "2)'On-the-ear' types [supra-aural] that couple against a lateral face of the auricle, or external ear, of the wearer;" and "3) 'Over-the-ear' types [circum-aural] that surround and form a closed chamber over the auricle of the listener." *See Skulley* (Ex. 1017), 1:22-34.

143. Consistent with my opinions discussed in Section VI.B.4 above, Skulley further corroborates that by 2008 headbands were conventional in many types of "[h]eadsets, particularly those of the two latter types [*i.e.*, on-the-ear and over-the-ear]" because the headband provides "structure…for forcefully maintaining the output face of the earphone in, against, or over the ear of the wearer." *Skulley* (Ex. 1017), 1:35-38.

D. Davis (Ex. 1033): U.S. Patent No. 5,761,298

144. According to the face of the document, Davis is a U.S. patent filed on May 31, 1996 (22), and issued on June 2, 1998 (45), titled "Communications Headset With Universally Adaptable Receiver And Voice Transmitter."

145. As I discussed above (Sections VI.B and IX.C), Davis is cited in Skulley at 1:27. Skulley states that Davis "describe[s]" "'in-the-ear' type earphones, sometimes referred to as 'ear buds,' which fit into the concha, or entrance to a wearer's middle ear." *See Skulley* (Ex. 1017), 1:24-27. As I discuss further below in this section, a POSA would agree that Davis discloses an in-the-ear type earphone (Davis also discloses other form factors, as I discuss below).

146. In its background section, Davis discloses that a "[c]ommunications headset can be used in a diversity of applications, and are particular effective for telephone operators, radio operators, aircraft personnel, and for other situations wherein it is desirable to support 'hands free' access to communications systems." *See Davis* (Ex. 1033), 1:10-14. Consistent with the opinions I offered in Section VI above, Davis further notes as background information the "[k]nown communications headset can be broadly characterized on the basis of several fundamental aspects of their design and function." *See Davis* (Ex. 1033), 1:16-18. One design characteristic Davis mentions is "whether the[headset] deliver[s] monoaural or binaural sound." *See Davis* (Ex. 1033), 1:18-19; *see also*

Section VI.A above (discussing one- and two-earphone headsets). Another characteristic of headphone design that Davis mentions is "whether the [headset] employ[s] invasive ear tip [*e.g.*, intra-aural] or a non-invasive loudspeaker [*e.g.*, supra- or circum-aural] in establishing a receiver-to-ear acoustical coupling." *See Davis* (Ex. 1033), 1:19-21; *see also* Sections VI.B.1-VI.B.3 above (discussing on-the-ear, over-the-ear, and in-the-ear designs). Another characteristic of headphone design that Davis mentions is "how they [headsets] are physically supported on the user." *See Davis* (Ex. 1033), 1:22-23; *see also* Sections VI.B.4-VI.B.5 above (discussing headband- and hanger-bar based designs). Davis also discloses that the headsets "acoustical characteristics" and "ergonomic qualities" are relevant characteristics of headset design. *See Davis* (Ex. 1033), 1:23-24; *see also, e.g.*, Section VI.B.1-VI.B.3 above (discussing the differences in sound isolation and user-differences in perceived comfort among on-the-ear, over-the-ear, and in-the-ear designs). A POSA would agree that all of the above were (and still are) relevant design considerations for a headset, including wireless headsets.

147. Davis also notes as background information that "headsets which deliver binaural sound (*i.e.*, ones which have acoustical transducers [*e.g.*, speakers] for both ears) may utilize some type of headband arrangement to secure receiver elements beside each ear." *See Davis* (Ex. 1033), 1:24-27; *see also* Section VI.B.4 above (discussing headband-based designs). Davis notes that headbands

"generally provid[e] very stable support for the headset" but, according to Davis, "headbands have the disadvantages that they increase the size and weight of the headset, and tend to be uncomfortable and obtrusive for the user." *See Davis* (Ex. 1033), 1:27-31. A POSA would agree that a benefit of a headband is that it helps "secure" the speaker elements against the user's ear, as I discussed above in Section VI.B.4. A POSA would also agree that some, but not all, users find a headband "uncomfortable and obtrusive." *Davis* (Ex. 1033), 1:27-31. A POSA would also agree with Davis (1:27-31) that, all other things being equal, a headband increases the size and weight of a headset, but a POSA also understood that headbands were often very simple and lightweight (*e.g.*, a thin piece of plastic or flat metal spring that carries wiring between the two earphones), as I discussed above in Section VI.B.4.

148. Davis notes that "[m]onoaural headsets (having only a single receiver situation near one ear) may be either right-handed or left-handed, or may incorporate a single design adaptable to left or right ear use." *See Davis* (Ex. 1033), 1:33-36. The same is true for a two-earphone (*e.g.*, stereo headphone) design: the form factor for each earphone was often a mirrored design (the same components but with the exterior shape designed for a left or right ear), but oftentimes an identical physical housing was used for the left and right earphones,

which could simplify the component supply requirements and production of the earphone.

149. Davis further notes that "[e]rgonomic considerations in the design of communications headset include the comfort of the device, the ease of putting the headset on and subsequently adjusting it for use" and that "[c]omfort and stability of the headset on the ear is [sic] believed to be among the most critical ergonomic considerations." *See Davis* (Ex. 1033), 1:48-55. Davis states that "[a]coustical qualities of communications headsets are often closely dependent on other aspects of the design." *See Davis* (Ex. 1033), 1:55-57. For example, "the acoustical quality of the sound heard by the user is clearly affected by the nature of the receiver-to-ear seal." *See Davis* (Ex. 1033), 1:55-60. For example, Davis notes that "[i]nvasive ear tips provide a good seal, but can suffer from problems of comfort and hygiene" whereas "[n]on-invasive loudspeaker-type receivers…are more susceptible to acoustical degradation from background-level sound and attenuation of the acoustical wave passing through open space from the receiver to the auditory meatus." *See Davis* (Ex. 1033), 1:59-65.

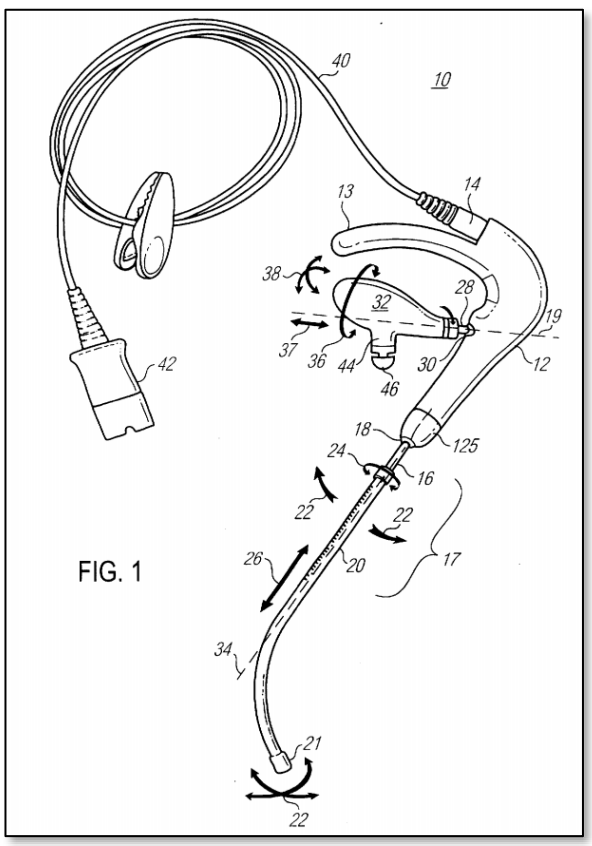
150. Thus Davis is consistent with, and further corroborates, my opinions above in Section VI, where I explain that in designing a headphone there were known tradeoffs along a variety of dimensions, such as sound quality, sound attenuation, aesthetics, weight, ease of fitting and comfort. Indeed, Davis notes

that "[g]iven the number of different considerations and constraints to be satisfied, it can be seen that headset design requires balancing many different, often competing considerations." *See Davis* (Ex. 1033), 2:6-8. This is particularly true because, as Davis explains, "it is well known that there are large variations in the physical characteristics of population in terms of the size, shape, and structure of the ear and the head, the position of the ear on the head, and other biometric concerns," and "[b]ecause of the large amount of variation between users, conventional approaches to headset design, particularly for earhook headset, tend to result in a headset that is comfortably and stably worn by only a fraction of the population of users." *Davis* (Ex. 1033), 2:9-17; *see also* 2:18-37 (explaining the "design tradeoffs" that depend, for example, on the "size of the concha, [or] the cavity surrounding the opening to the ear canal," of the user). In other words, a design that is comfortable for one user may be less comfortable for another user, which is why a POSA had reasons to implement a headset with particular functionalities in a variety of form factors.

151. In light of this background information, Davis states that "it is desirable to provide an earhook headset that is comfortable and stable for a large variety of users having varying physical characteristics, while providing high quality acoustic performance." *See Davis* (Ex. 1033), 2:38-42. Davis states that its "present invention" provides "a lightweight, self-supporting headset which can be

comfortably and securely fitted to a wide range of users without undue individual attention." *See Davis* (Ex. 1033), 2:45-49. Davis adds that this headset "may be easily adjusted and fitted so as [to] be worn comfortably and in a firm and stable fashion around the ear of a wearer." *See Davis* (Ex. 1033), 2:49-51. To achieve this, Davis discloses "a headset including a receiver enclosure carried by a headset enclosure having an arcuate [*i.e.*, curved] ear hook." *See Davis* (Ex. 1033), 2:52-55.

152. Davis's Figure 1 (below) illustrates an "one embodiment of a headset in accordance with the present invention." *See Davis* (Ex. 1033), 4:39-41.



As illustrated in Davis's Figure 1 above, "[h]eadset 10 includes a headset enclosure 12 having an arcuate earhook 13." *See Davis* (Ex. 1033), 4:41-42. "Headset enclosure 12 contains a first cavity (not shown) in which reside transmitter and receiver circuits." *See Davis* (Ex. 1033), 4:46-48. "The receiver enclosure 32 couples to the headset enclosure 12 by an attachment member," which in one embodiment "is a ball tube 28 extending from the receiver enclosure 32 to a socket 30." *See Davis* (Ex. 1033), 4:49-53. "Ball tube 28 and socket 30 together facilitate the angular adjustment of receiver enclosure 32 with respect to headset enclosure 12, as indicated by arrows 38"; "[t]his freedom of positioning enables the headset 10 to be adaptatively configured by a large variety of users." *See Davis* (Ex. 1033), 4:54-63.

153. Figure 8 (below) "is an illustration of a user positioning the receiver enclosure in the ear."

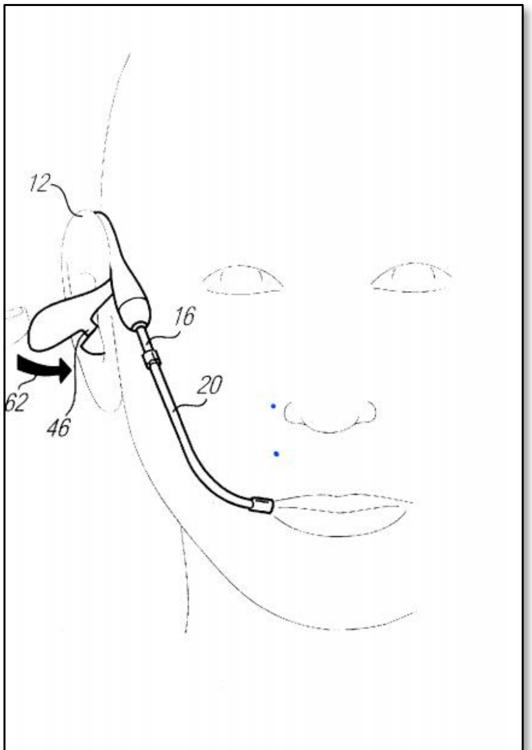


FIG. 8

As illustrated in Davis's Figure 8 above, the "earbud 46" is "adapted to rest against the opening of the ear canal" and thus sits partially in the ear (*i.e.*, in the concha region) of the user. *See Davis* (Ex. 1033), 6:32-35. As shown in Davis's Figure 8 above, "the receiver enclosure 32 is gently pushed toward the user's ear, as indicated by arrow 62 in FIG. 8, such that the earbud 46 comes to rest in the concha between the tragus and anti-tragus and directly in front of the opening of the ear canal." *See Davis* (Ex. 1033), 8:56-61.

154. Thus, as illustrated in Davis's Figure 1 and 8, Davis's "arcuate [*i.e.*, curved] earhook 13" is a curved hanger bar earphone. *See Davis* (Ex. 1033), 2:52-

55, 4:41-42. As shown in Davis's Figure 8, when worn by a user, earhook 13 (which is extending behind the user's ear in Figure 8) sits upon an upper external curvature of the user's ear, behind the upper portion of an "auricula" (*i.e.*, the auricle or pinna) of the user's ear. *See Davis* (Ex. 1033), 1:38 (noting that earhooks "fit[] around the ear"), 8:66-9:3 (explaining that "headset enclosure 12" provides support "behind the outer ear"), 10:8-9 ("a headset enclosure enclosing a first cavity adapted to ***curve partially around and behind*** a user's ear"). As also shown in Davis's Figures 1 and 8, Davis's headset includes a "body of the headset enclosure 12" (Ex. 1033, 4:41-42) that is connected to "earhook 13" (*i.e.*, an elongated, hanger bar portion that extends from the body portion) (Ex. 1033, 4:41-42), and the earphone extends from the body into the user's ear, when the headset is worn by the user. *See Davis* (Ex. 1033), 8:58-61 (noting that Figure 8 illustrates that "earbud 46 comes to rest in the concha…in front of the opening of the ear canal").

155. Davis also discloses that "[s]everal different configurations and sizes of earbuds 46 may be provided with the headset 10, such that an individual user can select one that he or she finds most preferable." *See Davis* (Ex. 1033), 6:43-46. To achieve this, "earbuds 46 are designed to be readily detachable from receiver enclosure 32." *See Davis* (Ex. 1033), 6:47-48. Davis reinforces the flexibility in this design by disclosing that "many substitutions, modifications and

alterations to the disclosed embodiment may be made without departing from the scope of the invention." *See Davis* (Ex. 1033), 9:39-41. "For example, the electronics may be mounted at various places within the headset enclosure and/or receiver enclosure." *See Davis* (Ex. 1033), 9:41-43. Davis similarly discloses that "the shape and size of both the headset enclosure and the receiver enclosure could vary." *See Davis* (Ex. 1033), 9:48-49.

156. Though Davis is primarily focused on a monoaural headset (Davis, 1:7-8), a POSA would have understood that Davis's form factor was adaptable for use in two-earphone (*e.g.*, stereo) headphone assemblies and that the same advantages Davis discloses for his design (*e.g.*, advantages in ergonomics and acoustical quality, Davis, 1:47-65), would have carried over to a two-earphone design (whether mono or stereo) that used one of Davis's form factors, based on Davis's teachings of techniques to achieve improved ergonomics and acoustic coupling of an earphone, as I explained above in this section.

157. Moreover, although Davis does not describe its hanger bar as being adjustable, such hanger bars were known in the art. For example, U.S. Patent No. 6,097,809 ("Lucey") (Ex. 1127) discloses a headset with an "adjustable ear support," *i.e.*, a hanger bar, "to fit a variety of ear sizes without affecting the balance of the ear support on the ear of the wearer." Abstract; *see also* 1:52-59, 4:37-67, FIGS. 1, 5. Also, U.S. Patent Application No. 2002/0041697

("MacDonald") (Ex. 1135) discloses "a flexible earhook," *i.e.*, a hanger bar, "for positioning an earphone adjacent a wearer's ear." *See MacDonald* (Ex. 1135), [0008]. As MacDonald explains, "[t]he hook element 101 is flexibly adjustable, which allows a wearer to adjust it to conform comfortably to the shape of his or her ear" and a "curved portion 106 may be shaped to make the fitting of the earhook 100 onto the wearer's ear comfortable." *See MacDonald* (Ex. 1135), [0022]-[0023], FIG. 1. Given Davis's focus on providing an adjustable headset that "comfortably and securely fitted to a wide range of users without undue individual attention" (*Davis* (Ex. 1033), 2:45-49) and which "may be easily adjusted and fitted so as [to] be worn comfortably and in a firm and stable fashion around the ear of a wearer" (*Davis* (Ex. 1033), 2:49-51), implementing Davis's hanger bar (or one similar thereto) as an adjustable hanger bar like the ones disclosed in, *e.g.*, in Lucey or MacDonald, would have been a routine design choice that Davis explicitly provided POSAs reason to make.

E. Oh (Ex. 1099): PCT Publication No. WO 2006/098584

158. According to the face of the document, Oh is a World International Property Organization (WIPO) application that published under the Patent Cooperation Treaty (PCT) in English on March 15, 2006, titled "Wireless Ear-Phone and Portable Terminal Using the Same."

159. Oh discusses art related to "wireless stereo earphone[s]" that can allow a user to "conveniently communicate" by putting the earphones "into the ears," effectively serving as wireless earbuds. *See Oh* (Ex. 1099), [01], [19]. Oh further notes that "wireless earphone[s]" and "wireless headset[s]" were known previously, specifically those that could be "inserted into a human'[s] ear." *See Oh* (Ex. 1099), [7]-[8] (citing examples).

160. Oh recognizes that it was known that "high quality stereo audio device[s]" that deviated away from "mono type earphone[s]" were in demand, and that wireless headsets should properly consist of two earphones each with a speaker. *See Oh* (Ex. 1099), [11]-[12]. As I discussed above in Section VI.A, a POSA would have agreed that by 2008 many conventional headphones were binaural (with two earphones and at least one speaker (*e.g.*, acoustic transducer) in each earphone), which was often used to achieve stereo sound (though it could have also been used for monoaural applications).

161. As I discussed in Section VI.C above, by 2008 it was known to implement a wireless headphone assembly in a completely wireless design, as taught by Oh, for the advantages discussed above in Section VI.C. Oh identifies an additional advantage whereby a user could replace just one of their completely wireless earphones when the user accidentally misplaced or broke one (but not both) of the earphones. *See Oh* (Ex. 1099), [41]. Thus, Oh's completely wireless

headphones provided the user with economic benefits because the user did not have to replace the entire headphone system when one earphone broke or was damaged or misplaced. *See Oh* (Ex. 1099), [41]. Rosener corroborates Oh's teachings and my opinions that a POSA had reasons to implement a wireless headphone in a fully wireless design by the mid-2000s. For example, Rosener disclosed that its conventional binaural wireless headset of Figure 2 "afford[ed] the benefits of wireless operation" but was still "physically connected by a headband," which "[s]ome users find…uncomfortable and/or disruptive to their headdress or coiffure." *See Rosener* (Ex. 1020), [0006]. As a proposed solution to drawbacks in conventional wireless headphones (*i.e.*, wireless headphones wherein the individual earphones are connected by wire or a headband), Rosener taught a completely wireless stereo headphone assembly "having no physical or electrical connection" between identical "audio data sinks" (*i.e.*, earphones) communicating with an audio source. *See Rosener* (Ex. 1020), [0011].

162. As discussed in Section VI.C above, implementing a fully wireless design only required a POSA's ordinary skill because the high-level form factor for the earphone design was largely independent of the choice between a wired, wireless, or fully wireless design.

163. Thus, as I discussed in Section VI.C above, by 2008, and additionally for the reasons stated above in this section, a POSA had reasons to implement a

wireless headphone assembly (*e.g.*, Rezvani-875's (*see* Section IX.A above) and Schrager's (*see* Section IX.F below)) in a completely wireless design, as taught by Oh.

F. Schrager (Ex. 1101): U.S. Patent No. 7,072,686

164. According to the face of the document, Schrager is a U.S. patent filed on August 9, 2002 (22), and issued on July 4, 2006 (45), titled "Voice Controlled Multimedia and Communications Device." Schrager relates to a voice-controlled multimedia and communications device (VCMCD) that "include[s] two primary components": "a headset unit 105" and a "base unit 110" that can "communicate with one another via wireless communication link 115," as illustrated in Schrager's FIG. 1 below. *Schrager* (Ex. 1101), 4:66-5:5.

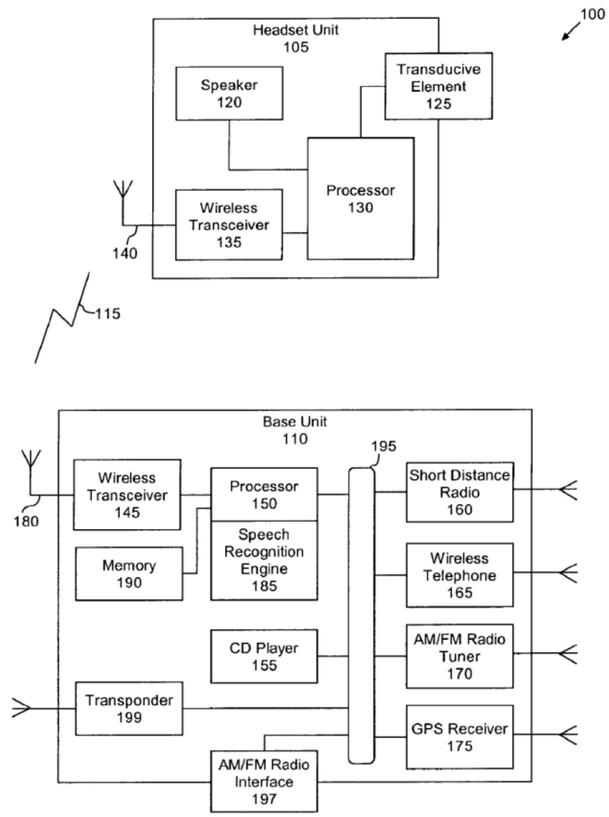


FIG. 1

165. The headset unit can include a "speaker 120 [an acoustic transducer] or other sound generator" that is "disposed in an earpiece portion of the headset unit" to "provide audio output when the headset 105 is worn by a user." *See Schrager* (Ex. 1101), 5:6-7, 5:8-11. Schrager also discloses that "[a]lthough not shown in FIG. 1, the headset unit 105 can include additional speakers so as to provide stereo sound," accordingly, by having "the headset…include two earpiece portions, each having a speaker disposed therein." *See Schrager* (Ex. 1101), 5:11-14.

166. Consistent with "provid[ing] stereo sound" (5:12-13), Schrager discloses that the function of portable electronic devices like Schrager's is to "listen to music" and play other "multimedia." *Schrager* (Ex. 1101), 1:21-22, 2:16-21, 3:56-60. Schrager discloses as background information that portable communications devices like Schrager's (*i.e.*, Schrager's base unit and headset unit) were known to be useful to consumers in a variety of situations, such as when travelling, "walking, jogging, hiking, bicycling, motorcycling, boating, or other activities" like "when engaged in sports" and other times when the user "must have one or more free hands." *Schrager* (Ex. 1101), 1:59-2:3. For that reason, a POSA had reason to implement Schrager's headset unit in any of the well-known form factors that I discussed above in Section VI.B (*i.e.*, on-the-ear, in-the-ear, and over-the-ear, and with or without a headband, and with or without a hanger bar as applicable) for the benefits I discussed in Section VI.B.

167. As I discussed in Section VI.B above, different users have different preferences in sound quality, sound attenuation, aesthetics, weight, ease of fitting and comfort associated with each form factor, which would have also motivated a POSA to implement Schrager's headphone assembly in each of the form factors that I discussed in Section VI.B above.

168. For example, as I discuss below in Section IX.G, Goldstein discloses earphones using "circum-aural [over-the-ear] or intra-aural [in-the-ear]" designs as

"Ear Mold Style[s]" (*i.e.*, form factors). *Goldstein* (Ex. 1026), [0043], [0048]. As I discussed above in Section IX.C, Skulley similarly discloses (1:22-34) that in addition to circum-aural ("over-the-ear") and intra-aural ("in-the-ear") designs, it was also conventional to use supra-aural ("on-the-ear") earphones, and that each of these form factors (in particular on-the-ear and over-the-ear) commonly used headbands connecting the earphones. *Skulley* (Ex. 1017), 1:35-38.

169. A POSA would have understood that the various situations Schrager describes would have benefitted from one or more of these form factors, for the reasons I discussed in Sections VI.B.1-VI.B.4. For example, as I discussed above in Section VI.B.2, over-the-ear designs provided passive sound attenuation and often connected the earphones by a headband for the benefits a headband provides (*see* Section VI.B.4 above discussing headbands). A POSA understood that implementing Schrager's headset in an over-the-ear design, such as taught by Skulley (Section IX.C above) or Goldstein (Section IX.G below), would have been beneficial, for example, while operating an off-road vehicle or riding mower, which can be very loud, and that the effects of jostling while riding said vehicle or mower would have been mitigated from the stability a headband (or a hanger-bar) provides to maintain the earphones on the user's head. Similarly, in Section VI.B.3, I explained that an in-the-ear (earbud) design also generally provided improved sound delivery and noise reduction and that because they generally had

small form factors, in-the-ear designs were generally lighter, smaller and less obtrusive than on-the-ear and in-the-ear designs. Thus, a POSA understood that implementing Schrager's headset in an in-the-ear design, such as taught by Davis (Section IX.D above), Skulley (Section IX.C above) or Goldstein (Section IX.G below), would have benefits, for example, when traveling or walking. As I discussed above in Section VI.B.1, on-the-ear designs were also typically lighter than over-the-ear designs and typically incorporated a headband. Thus, a POSA understood implementing Schrager's headset in an on-the-ear design, such as described in Skulley *(*1:28-31), would have also had benefits when travelling in road vehicles or riding on an off-road vehicle.

170. As I discussed in Section VI.B.5 above, by 2008 another common form factor for a headphone assembly was one that included a curved hanger bar (that could be adjustable) that sits upon an upper external curvature of a user's ear, and in some designs behind the upper portion of an auricula (*i.e.*, auricle or pinna) of the user's ear, when the headphone assembly is worn by the user. As I discussed above in Section IX.D, for example, Davis discloses an earphone design with a curved hanger bar that sits upon an upper external curvature of a user's external ear (*i.e.*, auricle or pinna), which Davis uses with an in-the-ear earphone design. *See* Section IX.D above (discussing Davis's FIGS. 1, 8). As I discussed above in Sections VI.B.5 and IX.D, adjustable hanger-bar designs had known

benefits (*e.g.*, the hanger bar kept the earphone adjacent to the user's ear, and by being adjustable, the hanger bar could be made to fit a variety of ear and head shapes). As I discussed above in Section VI.B.5, examples of this adjustability are disclosed by Lucey (Ex. 1127, Abstract; see also 1:52-59, 4:37-67, FIGS. 1, 5) and MacDonald (Ex. 1135, [0008], [0022]-[0023], FIG. 1); *see also* Section IX.D above (discussing Lucey and MacDonald). Thus, a POSA understood there would have been benefits to implementing Schrager's headphone assembly in a hanger-bar design (as taught by Davis, *see, e.g.*, Davis, FIGS. 1 and 8 Section IX.D above) using an in-the-ear form factor (as taught by Davis, *see, e.g.*, Davis, FIGS. 1 and 8 Section IX.D above), where the hanger bar was adjustable (*see* Section VI.B.5 above, citing Ex. 1127 and Ex. 1135) and using Goldstein's BTE design (*see, e.g.*, Goldstein, [0043] and Section IX.G below).

171. As I discussed above in Section VI.B.4, to achieve stereo sound in a headphone assembly like Schrager's, the earphones were often connected by a connection wire (often carried by a headband) to bring the stereo signals to each earphone, as corroborated by Rutschman (Ex. 1050), [0007]-[0008] and Huddart-2 (Ex. 1041), [0002]. A POSA understood there would have been benefits to implementing Schrager's stereo headphone assembly with connection wires (*e.g.*, to achieve stereo sound) and carrying those connection wires in a headband (*e.g.*, to protect the connection wires when traveling, walking, or hiking, etc.), as was

well-known in the art (Section VI.B.4 above) and suggested by Goldstein's teachings (Section IX.G below).

172. As I discussed above in Section VI.C, it was also known by 2008 to implement headphone assemblies in fully wireless designs (*i.e.*, without a connection wire between earphones), such as taught by Oh (Ex. 1099, *see* Section IX.E above) and Rosener (Ex. 1020, *see* Section VI.C above), for the benefits that I discussed above in Section VI.C. For example, a POSA understood that a true-wireless design would have been beneficial to a variety of Schrager's use cases (*e.g.*, traveling, jogging or riding a motorcycle (where legal to wear a headphone while on a motorcycle)) to avoid tangling the wire and the weight and rigidity of a headband. Thus, a POSA understood there would have been benefits to implementing Schrager's headphone assembly in a fully wireless design, such as taught by Oh (*see* Section IX.E above).

173. Moreover, as I discussed above in Sections VI.B-VI.C, each of above form-factors were known and common in the art by 2008. Thus, implementing Schrager's headset in any of these form factors would have been applying a known technique to improve similar devices in the same way (*i.e.*, to provide a headphone assembly in each of these well-known form factors).

174. A POSA would have also found implementing Schrager's headset in each of these form-factors obvious to try because, as I discussed above in Sections

VI.B-VI.C, each was one of a finite number of predictable configurations for a headphone assembly.

175. In my opinion, a POSA would have only required ordinary skill to implement Schrager's headset in any of the well-known form factors discussed in Sections VI.B-VI.C because, as I demonstrated above those sections each was a well-known, conventional configuration for a headphone by the mid-2000s.

176. Schrager discloses a "transducive element 125, for example a microphone…attached to the headset unit 105." *Schrager* (Ex. 1101), 5:5-7, 5:15-16. Schrager's transducive element (microphone) "receive[s] "a user spoken utterance," which is "transmitted to a base unit via a wired connection or a short distance wireless communication link." *Schrager* (Ex. 1101), 3:27-32. "[T]he transducive element 125 can be located on an arm which is rotatably attached to the earpiece so as to swing up and away from a user's face when not in use." *Schrager* (Ex. 1101), 5:17-20. Moreover, as I discussed above in Section VI.D it was common by 2008 to include user controls to activate microphones. Thus, a POSA had reasons to include in Schrager's headset functionality to allow the user to activate Schrager's microphone (*e.g.*, a button or a switch activated by the rotation), for the reasons I discussed above in Section VI.D (*e.g.*, to save battery power).

177. Schrager also discloses "one or more control buttons and/or switches" located on the "exterior of the headset unit." The controls can be configured to "give precedence to audio input received from the transducive element [microphone]" and thereby "[serve] as an indication that the user will speak." *See Schrager* (Ex. 1101), 6:37-38, 6:46-49, 9:59-61. As I discussed in Section VI.D, by 2008 it was common for headsets to include controls that allow a user to manually indicate when user input (*e.g.*, speech) will be provided to the headset, in order to activate the microphone (*e.g.*, for push-to-talk applications). As I discuss in Section IX.G below, Goldstein ([0069]) discloses an example—"a first user interaction element 530 (*e.g.*, a button), that can be used to turn the earpiece 500 on." Goldstein's 'power' button is consistent with my opinions discussed in Section VI.D above that it was known to activate/deactivate the microphone (or all electronics) by a control for the benefits of saving battery power and avoiding pick-up of unwanted ambient sounds when the user was not actually speaking.

G. Goldstein: (Ex. 1026): U.S. Patent Application Publication No. 2008/0031475

178. According to the face of the document, Goldstein is a U.S. published patent application filed on July 9, 2007, and published on February 7, 2008, titled "Personal Audio Assistant Device and Method."

179. Goldstein describes headphones having "a pair of transducers" that "use speakers placed in close proximity to the ears (hence the name earphone) to

convert the signal into audible sound waves." *Goldstein* (Ex. 1026), [0048]. Goldstein also discloses headphones can be "placed either circum-aural [over-the-ear] or intra-aural [in-the-ear]." *See Goldstein* (Ex. 1026), [0048].

180. Goldstein's Figure 2 (below) is consistent with intra-aural, circum-aural, and supra-aural earphones, but (at least visually) suggests supra-aural headphones because the round discs on the sides of the user's ears appear to be resting on the user's ears instead of being placed in or around the user's ears, as with intra-aural or circum-aural forms, respectively.

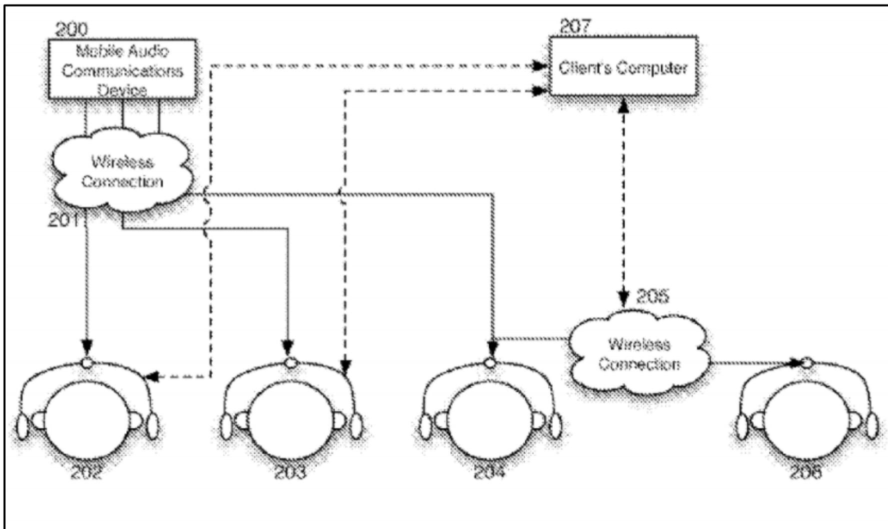
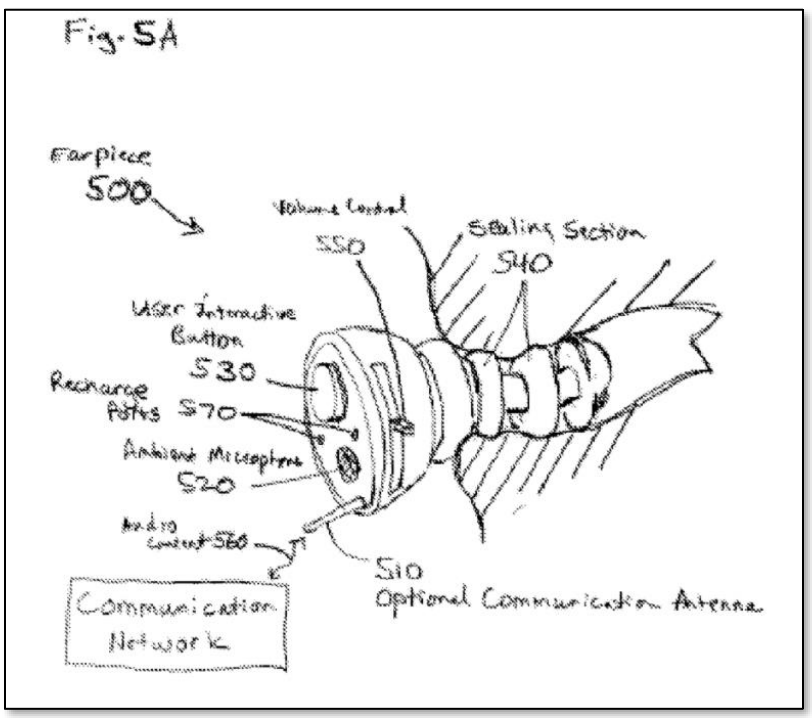


Fig. 2

181. The earphones in Figure 2 appear to be connected with a headband or wire. As I discussed in Section VI.B.4 above, unless implemented as a fully wireless design (Section VI.C), a POSA understood that the typical way to implement a stereo headset like Schrager's (*see* Section IX.F above) or Goldstein's

(Goldstein, [0048]) would have been with wiring located between the earphones. If Goldstein's earphones were not connected by a headband and/or wire, a headband carrying the wiring was common by the mid-2000s for headphones, especially on-the-ear and over-the-ear types, for the advantages I discussed in Section VI.B.4 above, (*e.g.*, to provide structure to maintain the earphone on the user's head and protect the connection wire between the earphones).

182. Goldstein illustrates an in-the-ear (intra-aural) type of earphone in Figure 5A (copied below).



As shown in Figure 5A above, Goldstein's in-the-ear design has an earphone with a body portion that sits near to or partially in the concha of the user. As shown in Figure 5A above, the earphone has an extended portion that extends from the body of the earphone's housing into the ear canal, similar to the examples I discuss in Section VI.B.3 above. As also shown in Figure 5A above, Goldstein's earpiece (*i.e.*, earphone) has various electrical components, including an "ambient microphone 520" and "a first user interaction element 530 (*e.g.*, a button), that can be used to turn the earpiece on, or if on then activate an audio play command to start playing saved audio content." *Goldstein* (Ex. 1026), [0069]).

183. In addition to the in-the-ear (intra-aural) design shown in Figure 5A, Goldstein also discloses using an intra-aural form factor in a "behind the ear (BTE)" design. *Goldstein* (Ex. 1026), [0043], [0078], [0090]. A POSA would have understood Goldstein's behind-the-ear design to be referring to a hanger-bar (earloop or earhook) design because, as I discussed in Section VI.B.5 above, the hanger bar (*i.e.*, earhook or earloop) typically extends from the body portion of the earphone and is elongated to sit behind and over the user's pinna. Figure 1 of Davis (Ex. 1033), for example, depicts a conventional hanger bar earphone design with an elongated portion of the earphone sitting behind and over the user's outer ear. Likewise, Figure 1 of Saito (Ex. 1113) discloses a conventional hanger bar earphone design with an elongated portion (element "hook" 12) of the earphone sitting behind and over the user's pinna, using a "behind-the-ear type hearing aid" and "[t]he hook 12 also has a shape suitable for hanging the main body 10 on the upper portion of the earlobe of the user with the … main body 10 substantially

engaged by the outer root of the earlobe." *See Saito* (Ex. 1113), 2:43-50, 2:64-68, FIG 1. Furthermore, Saito (Ex. 1113) also discloses an intra-aural form factor in a "behind the ear (BTE)" design, with its inclusion of an earplug that enters the ear canal, as follows "[t]he hook 12 has a sound passageway (not shown) extending therethrough to reach the earphone (not shown) and a free end portion connected via a sound conducting tube 16 to an ear plug 18." *See Saito* (Ex. 1113), 2:60-64, FIG 1. Given the conventional nature of the design, a POSA would have understood Goldstein's intra-aural form factor in a "behind the ear (BTE)" design to be a hanger-bar design with an elongated earphone portion sitting behind and over the user's pinna similar to the designs depicted in Saito and Davis.

* * *

184. I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

I declare under penalty of perjury that the foregoing is true and correct.

John G. Casali

Dated: March 1, 2021 ________________________

John G. Casali, Ph.D., CPE