**IN THE UNITED STATES DISTRICT COURT**
**FOR THE WESTERN DISTRICT OF TEXAS**
**WACO DIVISION**

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| EIGHT KHZ, LLC,<br>Plaintiff,<br><br>v.<br><br>META PLATFORMS, INC.; META PLATFORMS TECHNOLOGIES, LLC; TWISTED PIXEL GAMES, LLC,<br>Defendants. | Civil Action No. 6:22-CV-00575-ADA |

# DEFENDANTS' FIRST AMENDED INVALIDITY CONTENTIONS

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Defendants Meta Platforms, Inc., Meta Platforms Technologies, LLC, and Twisted Pixel Games (collectively, "Defendants") hereby serve these invalidity contentions addressing Plaintiff Eight kHz, LLC's ("8K" or "Plaintiff") nine asserted patents—U.S. Patent No. 9,226,090 (the "'090 Patent"), U.S. Patent No. 9,282,196 (the "'196 Patent"), U.S. Patent No. 9,674,628 (the "'628 Patent"), U.S. Patent No. 10,448,184 (the "'184 Patent"), U.S. Patent No. 10,368,179 (the "'179 Patent"), U.S. Patent No. 10,917,737 (the "'737 Patent"), U.S. Patent No. 10,798,509 (the "'509 Patent"), U.S. Patent No. 11,172,316 (the "'316 Patent"), and U.S. Patent No. 11,290,836 (the "'836 Patent") (collectively, the "Asserted Patents").

In accordance with the Court's Standing Order Governing Proceedings (OGP) 4.2 – Patent Cases, Defendants' contentions include: (1) charts setting forth where in prior art references each element of the Asserted Claims is found,[1] (2) identifications of limitations Defendants contends are indefinite or lack written description under 35 U.S.C. § 112 ("§ 112" or "Sec. 112"), and (3) identifications of claims Defendants contend are directed to ineligible subject matter under 35 U.S.C. § 101 ("§ 101" or "Section 101"). Defendants also are concurrently producing documents in accordance with by OGP 4.2, Section II ¶ 4. With their November 11, 2022 preliminary contentions, Defendants made productions and provided source code for the Accused Instrumentalities available for inspection, by appointment, at Latham & Watkins' Silicon Valley office, without any representations as to the accuracy, completeness, or applicability to Defendants' current source code. Additionally, Defendants made prior art devices, as addressed below, available for inspection, by appointment, at Latham & Watkins' Washington D.C. office.

These first amended contentions hereby incorporate Defendants' November 11, 2022

[1] Charts cited herein are being provided with service of these first amended contentions, or were provided with Defendants' November 11, 2022 preliminary contentions.



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preliminary contentions, including any and all claim charts, by reference.

## I. GENERAL STATEMENT AND RESERVATIONS OF RIGHTS

### A. Asserted Claims And Current State Of Plaintiff's Contentions

In its Preliminary Infringement Contentions, Plaintiff identified the claims shown in the table below as allegedly infringed. Defendants refer to these claims as the "Asserted Claims."

| Asserted Patent | Asserted Claims |
|---|---|
| '196 Patent | Claims 1, 4, 15, 19 |
| '628 Patent | Claims 9, 12, 16 |
| '090 Patent | Claims 8, 14, 15 |
| '184 Patent | Claim 14 |
| '179 Patent | Claim 14 |
| '737 Patent | Claims 1, 14, 15, 16 |
| '509 Patent | Claims 9, 10, 17 |
| '316 Patent | Claims 9, 10, 14 |
| '836 Patent | Claims 8, 10 |

Defendants provide these invalidity contentions without waiving any right to modify, amend, and/or supplement them in view of any alteration(s) Plaintiff makes to its infringement contentions and disclosures required under OGP 4.2, Sec. II ¶ 2. Plaintiff's contentions and disclosures to date are deficient in multiple respects and do not provide Defendants with sufficient information to fully understand what specific products, features, and components are accused, or the alleged factual and evidentiary bases for Plaintiff's claims.

For example, in contravention of OGP 4.2, Sec. II ¶ 2, Plaintiff failed to produce any documents regarding conception or reduction to practice. Thus, Defendants understand that Plaintiff (i) has no evidence of the conception, reduction to practice, design, or development of the alleged inventions recited in the Asserted Claims and (ii) is not contending that any of the Asserted Claims are entitled to priority dates earlier than the purported priority dates identified on the Asserted Patents themselves. Furthermore, as discussed in more detail herein, at least the Asserted Claims of the '737, '509, and '316 Patents are not entitled to the priority dates Plaintiff asserts.



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Rather, the Asserted Claims of the '737, '509, and '316 patent are not entitled to claim priority to any dates before August 31, 2019, July 25, 2020, and October 5, 2020, respectively. Plaintiff still has not remedied these deficiencies that were identified at least as early as Defendants' November 11, 2022 preliminary contentions, and on multiple occasions in correspondence between the parties since then.

As another example, Plaintiff's infringement contentions fail to adequately explain Plaintiff's theories for a number of accused products, applications, and claimed features of the Asserted Claims. And throughout its contentions for the products and/or applications that Plaintiff did attempt to address, Plaintiff parrots claim language and cuts and pastes portions Defendants' and other documents and information, without any explanation of the significance of the information it cuts and pastes (e.g., an explanation of *how* such information allegedly satisfies and/or relates to pertinent claim language). Plaintiff also made no effort to demonstrate that each accused product and/or application it chose to chart has the same functionalities or implementations as accused products and/or applications Plaintiff unjustifiably chose not to chart. Plaintiff has thus prejudiced Defendants' ability to understand, for purposes of preparing these invalidity contentions, what Plaintiff alleges to be the scope of the Asserted Claims. Again, Plaintiff still has not remedied these deficiencies that were identified at least as early as Defendants' November 11, 2022 preliminary contentions, and on multiple occasions in correspondence between the parties since then. Consequently, Defendants have in some circumstances interpreted limitations in the Asserted Claims as though they possess the scope implicit in Plaintiff's infringement contentions, notwithstanding the fact that Plaintiff's apparent infringement theories contradict the teachings of the Asserted Patents, contradict the meanings a person of ordinary skill in the art (a "POSA") would attribute to the Asserted Claims, are internally



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inconsistent, and are vague and/or conclusory concerning how certain limitations supposedly read on the accused products and applications.

**B. Claim Construction**

The Court has not yet construed the Asserted Claims. Defendants reserve all rights to modify, amend, and/or supplement these contentions after any claim construction ruling. Defendants' contentions do not represent Defendants' agreement or view as to the meaning of any claim term. For example, to the extent that Defendants assert that prior art is anticipatory and/or renders obvious claims based on constructions apparently applied by Plaintiff to the Asserted Claims, e.g., in Plaintiff's deficient preliminary infringement contentions, Defendants' invalidity contentions are not—and should not be interpreted as—adoptions or admissions as to the accuracy of that scope or any constructions. Relatedly, Defendants do not concede that Plaintiff's apparent constructions are proper, Defendants may contest any such apparent constructions, and Defendants do not admit that any accused product, application, or service, or any of Defendants' other products or services, infringes any of the Asserted Claims of the Asserted Patents. In short, Defendants' invalidity contentions are not, and should in no way be seen as, admissions or adoptions as to any particular claim scope or construction, any priority date, any admission that any claims have been properly asserted in this case, or as any admission that any aspect of any accused product or application meets any particular claim element in any particular way. Defendants object to any attempt to imply claim construction from their invalidity contentions, including from accompanying claim charts. Claim construction will be addressed in due course.

Furthermore, Defendants' invalidity contentions are made under a variety of alternatives and do not represent Defendants' agreement or view as to the meaning, definiteness, written description support for, or enablement of any limitation of any Asserted Claim. Thus, nothing in these invalidity contentions should be interpreted as an admission that any claim or limitation



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satisfies the written description, enablement, or definiteness requirements, or the requirements associated with means-plus-function claims, pursuant to § 112. Similarly, nothing in these contentions concerning the failure of any claim or limitation to satisfy § 112 should be interpreted as an admission that any element in the prior art fails to disclose any limitation in the Asserted Claims.

### C. Doctrine Of Equivalents

In its infringement contentions, Plaintiff alleged literal infringement of every element of the Asserted Claims, and Plaintiff provided only cursory and improper reservations of rights with respect to the Doctrine of Equivalents, cutting and pasting boilerplate recitations of the tests for this doctrine without any associated explanation. Because Plaintiff has failed to explain how any claim element is supposedly met under the Doctrine of Equivalents, Defendants understand that Plaintiff is not actually alleging infringement under the Doctrine of Equivalents. Should Plaintiff attempt to assert any additional allegations of infringement under the Doctrine of Equivalents, Defendants may amend and supplement these invalidity contentions to address any such improperly withheld theories, as appropriate. Defendants raised these issues with Plaintiff at least as early as Defendants' November 11, 2022 preliminary contentions, and on multiple occasions in correspondence between the parties since then, but Plaintiff still has not remedied these deficiencies in its infringement contentions.

### D. Ongoing Discovery and Disclosures

Defendants provide these contentions based on their present understanding of the Asserted Patents, Plaintiff's express and/or implicit interpretations of same, and pertinent prior art. Defendants' investigation of the Asserted Patents, Plaintiff's claims, and grounds for invalidity is ongoing, and Defendants have not completed their investigation of the facts and documents relating to this action or their preparation for trial. Defendants thus reserve the right to supplement,



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amend, and/or modify these invalidity contentions as this case and discovery progress and as additional research and investigation is conducted, including to identify prior art not included in this disclosure, e.g., additional prior art systems, including but not limited Defendants' own prior art systems and third-party prior art systems. Defendants likewise reserve the right to supplement, amend, and/or modify these contentions to assert additional defenses under 35 U.S.C. §§ 101, 102, 103, and/or 112, including in response to Plaintiff's further explanation of its infringement claims, priority claims, and claim construction positions; to the extent Plaintiff produces any additional invalidity-related information or documents in response to these contentions, in response to Defendants' discovery requests, or otherwise; in response to Court orders, e.g., any *Markman* order(s); and as otherwise permitted under the Federal Rules of Civil Procedure, Local Rules, and/or the Court's orders.

In addition, Defendants incorporate by reference the relevant testimony of any fact witnesses, including third parties, who are or have been deposed, provide declarations, or otherwise testify in this lawsuit (or a related litigation). Defendants also incorporate by reference the declarations, reports, and testimony of any expert witnesses who opine on Defendants' behalf regarding invalidity of the Asserted Patents.

**E. Additional Reservations Of Rights**

The invalidity claim charts provided with these contentions—which for the avoidance of doubt are incorporated by reference as if fully set forth herein—identify specific instances where prior art references disclose, either expressly, implicitly, or inherently, each limitation of the Asserted Claims and/or examples of disclosures in view of which a POSA would have considered each limitation obvious. Citations included in those charts for independent claims necessarily apply to associated dependent claims. Similarly, citations included in those charts for certain limitations also apply to other, related limitations. Defendants have endeavored to identify the



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most relevant portions of the references, based on their investigation to date, but the references may contain additional support for particular claim limitations. Defendants may rely on uncited portions of the prior art references, other documents, and/or systems, as well as fact and expert testimony, to provide context or to aid in understanding the cited portions of the references. For example, where Defendants identify a particular figure in a prior art reference, the identification should be understood to encompass the caption and description of the figure, as well as any text relating to the figure in addition to the figure itself. Similarly, where an identified portion of text refers to a figure or other material, the identification should be understood to include the referenced figure or other material as well. It should be recognized that a POSA would generally read a prior art reference as a whole and in the context of other publications, literature, and general knowledge in the field, including any/all publications and other references cited and/or incorporated by reference therein. Defendants also may rely on any prior art system referenced, embodied, or described in any of the prior art references identified herein, or which embodies any of the prior art references identified herein. In addition, Defendants may rely on admissions concerning the scope of the prior art relevant to the Asserted Patents found in, among other things, the Asserted Patents' specifications; the prosecution histories of the Asserted Patents and any related patents and/or patent applications, including foreign counterparts; any testimony or declarations of the named inventors of the Asserted Patents or related patents and applications; and any papers or evidence submitted by Plaintiff in connection with this litigation or other past, pending, or future litigation brought by Plaintiff involving the Asserted Patents or related patents, including any post-grant review proceedings involving the Asserted Patents or related patents.

Defendants contend that each of the Asserted Claims is invalid under at least 35 U.S.C. §§ 102 and/or 103, and these invalidity contentions set out prior art and information demonstrating



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same. However, a POSA views items of prior art and such information in the context of their experience, training, and other publications, literature, and products. Accordingly, Defendants reserve the right to rely on prior art not cited in these contentions, as well as on other publications and expert testimony, to aid in the understanding and interpretation of prior art and information cited and discussed herein, e.g., to provide context for same, showings relating to the state of the art, and as additional evidence that particular claim limitations would have been known, obvious, and/or were disclosed. Defendants further reserve the right to rely on uncited portions of the prior art discussed in these contentions, other publications, and testimony to establish bases for combinations of prior art that render the Asserted Claims obvious.

Defendants incorporate by reference, in full, all prior art references and related patents (e.g., any patent that issued from any parent or ancestral application related in any way to a given patent and any continuing application, continuation-in-part application, divisional application, file-wrapper continuation, reexamination proceeding, reissue application, abandoned application or foreign counterpart application for that patent) cited in the Asserted Patents, their prosecution histories, and all references cited therein.

The following invalidity contentions are provided subject to the foregoing statements and qualifications.

## II. ALLEGED PRIORITY DATES

The table below shows the priority dates to which Plaintiff contends the Asserted Claim of the Asserted Patents are entitled.

| Asserted Patent | Plaintiff's Asserted Priority Date |
|---|---|
| '196 Patent | June 23, 2014 |
| '628 Patent | June 23, 2014 |
| '090 Patent | June 23, 2014 |
| '184 Patent | December 27, 2015 |



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| ’179 Patent | December 27, 2015 |
| ’737 Patent | June 10, 2016 |
| ’509 Patent | February 20, 2016 |
| ’316 Patent | February 20, 2016 |
| ’836 Patent | May 24, 2017 |

At least the Asserted Claims from the ’737, ’509, and ’316 patents are not entitled to the priority dates Plaintiff asserts. As noted above, the Asserted Claims of the ’737, ’509, and ’316 patent are not entitled to claim priority to any dates before August 31, 2019, July 25, 2020, and October 5, 2020, respectively.

Although the Asserted Claims of the ’737 Patent purport to claim priority, through a series of continuations, to a provisional application filed June 10, 2016, that provisional application—U.S. Provisional Patent No. 62/348,164 (the “’164 Provisional”)—lacks written description support for the Asserted Claims. For example, the Asserted Claims of the ’737 Patent require “a wearable electronic device (WED) worn on a head of a user” that tracks movement of a portable electronic device (PED) held by a user; movement of the PED to define the shape or boundary of a 3D zone around the user; and a 3D zone extending from a physical floor under the user. The ’164 Provisional does not disclose or describe any of these features:

- **WED tracks movement of a portable electronic device (PED) held by a user:** The ’164 Provisional discloses only WEDs such as headphones, “a head mounted display,” and “ear-mounted microphones,” and none of the disclosed WEDs tracks movement of a PED held by the user.
- **Movement of the PED defines the shape or boundary of a 3D zone around the user:** The ’164 Provisional discloses “zones” as “areas [that] represent locations where a user perceives sound to originate or localize,” and in relation to a user’s head or face. It discusses various electronic devices, such as headphones, speakers, and head-mounted displays, but it does not disclose or describe that a user can define a 3D zone by holding a device and moving it around. Rather, the ’164 Provisional merely states that “a software program” may “defin[e] (including a size, a shape, a location, and a number) zones or SLPs around a head of listener”; there is no description of such parameters being defined based on movement of a handheld device. The ’164 Provisional discloses “[a] room scanner or application in communication with a camera on a device scans the surroundings (such as the room or space, and nearby space such as a desk).” But it further discloses this is



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performed "to calculate an appropriate selection of an RIR/BRIR" (binaural room impulse response)—not to define the shape or boundary of a 3D zone.

- **3D zone extends from the physical floor under the user:** The '164 Provisional discloses that zones can have various shapes and sizes, but it never discloses defining a zone that extends from the floor on which a user is standing.

Additionally and alternatively, the Asserted Claims of the '737 Patent are not entitled to any priority dates between November 30, 2016 and the August 31, 2019 filing date of the '737 Patent's application, U.S. Patent Application No. 16/558,088 ("the '088 Application"), or even a priority date of August 31, 2019 based on the '088 Application's filing. As noted in Section VII.F, there is inadequate written description support for the Asserted Claims in the '737 Patent's specification (or any of the earlier specifications in that patent's family).

The Asserted Claims of the '509 Patent are not entitled to any priority dates between February 20, 2016 (Plaintiff's earliest claimed priority date) and the July 25, 2020 filing date of the '509 Patent's application, U.S. Patent Application No. 16/938,936 (the "'936 Application"), or even a priority date of July 25, 2020 based on the '936 Application's filing. As noted in Section VII.G, there is inadequate written description support for the Asserted Claims in the '509 Patent's specification (or any of the earlier specifications in that patent's family).

The Asserted Claims of the '316 Patent are not entitled to any priority dates between February 20, 2016 (Plaintiff's earliest claimed priority date) and the October 5, 2020 filing date of the '316 Patent's application, U.S. Patent Application No. 17/062,633 (the "'633 Application"), or even a priority date of October 5, 2020 based on the '633 Application's filing. As noted in Section VII.H, there is inadequate written description support for the Asserted Claims in the '316 Patent's specification (or any of the earlier specifications in that patent's family).

## III. DISCLOSURE OF PRIOR ART

The prior art references and systems identified below disclose and/or render obvious the



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limitations of the Asserted Claims of the Asserted Patents explicitly, inherently, or as part of a combination, and may also be relied on to show the state of the art at the relevant times. Defendants may rely on these references, as well as any references they cite or incorporate or to which they relate, including related patent applications and issued patents (e.g., published U.S. patent applications, and issued U.S. patents, foreign applications or issued patents). For example, any citation to or quotation from any prior art reference should be understood to encompass related references, e.g., parallel citations to related patent applications and patents. Thus, where a claim chart cites a published patent application that ultimately issues as a patent with substantially the same specification, for example, Defendants may rely on the published patent application or the issued patent. Defendants also may rely on persons identified as inventors of the prior art patents, authors of the prior art publications, individuals with personal knowledge of prior art systems, and/or others, as such individuals are identified through further discovery. In addition, Defendants may rely on the facts developed in discovery of prior invention, including by Meta, e.g., through early prototypes of the accused Oculus devices (or other similar devices) and related software. Similarly, Plaintiff has not yet provided discovery on products allegedly embodying the Asserted Patents and Asserted Claims that may have been publicly used, disclosed, or offered for sale or sold prior to the alleged or applicable priority dates of the Asserted Claims. Defendants reserve the right to supplement, amend, and/or modify these contentions based on such future discovery.

The following subsections identify prior art by Asserted Patent; however, as many of the references cited in these subsections are pertinent to multiple Asserted Patents, if not all of the Asserted Patents, Defendants reserve the right to rely on references cited below in invalidity challenges to Asserted Claims of any of the Asserted Patents, regardless of the subsection in which references appear in these invalidity contentions.



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### A. The ’196 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more claims of the Asserted Claims of the ’196 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 6,961,439 (“Ballas 439”) | U.S. | Nov. 1, 2005 | A-01 |
| U.S. Patent No. 9,632,683 (“Jarvinen”) | U.S. | Apr. 25, 2017 | A-02 |
| U.S. Patent No. 9,307,331 (“Pedersen”) | U.S. | Apr. 5, 2016 | A-03 |
| U.S Patent Pub. No. 2010/0328419 (“Etter 419”) | U.S. | Dec. 30, 2010 | A-04 |
| U.S. Patent No. 8,406,439 (“Bedingfield”) | U.S. | Mar. 26, 2013 | A-05 |
| U.S. Patent Pub. No. 2009/0052703 (“Hammershoi”) | U.S. | Feb. 26, 2009 | A-06 |
| U.S. Patent No. 8,559,646 (“Gardner”) | U.S. | Oct. 15, 2013 | A-08 |
| U.S. Patent No. 9,961,208 (“Boustead”) | U.S. | May 1, 2018 | A-09 |
| U.S. Patent No. 6,850,496 (“Knappe”) | U.S. | Feb. 1, 2005 | A-10 |
| U.S. Patent No. 9,131,305 (“Li 305”) | U.S. | Sept. 8, 2015 | A-11 |
| U.S. Patent No. 9,118,991 (“Nystrom”) | U.S. | Aug. 25, 2015 | A-12 |
| U.S. Patent No. 7,606,375 (“Bailey”) | U.S. | Oct. 29, 2009 | A-13 |
| U.S. Patent No. 8,797,386 (“Chou”) | U.S. | Aug. 5, 2014 | Addressed as appropriate |
| U.S. Patent No. 9,578,440 (“Otto 440”) | U.S. | Feb. 21, 2017 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 (“Flaks 968”) | U.S. | July 1, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,818,000 (“Andrea”) | U.S. | Aug. 26, 2014 | Addressed as appropriate |
| U.S. Patent No. 7,415,123 (“Ballas 123”) | U.S. | Aug. 19, 2008 | Addressed as appropriate |
| U.S. Patent Pub. No. 2008/0273709 (“Sandgren”) | U.S. | Nov. 6, 2008 | Addressed as appropriate |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent Pub. No. 2014/0064526 ("Otto 526") | U.S. | Mar. 6, 2014 | Addressed as appropriate |

| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | A-07 |
| A Wearable Spatial Conferencing Space ("Billinghurst 1998") | 1998 | Billinghurst; IEEE | Addressed as appropriate |
| Real-time Head-tracked 3D Audio with Unlimited Simultaneous Sounds ("Jin") | 2005 | Jin; ICAD | Addressed as appropriate |
| An Experimental Study on the Role of 3D Sound in Augmented Reality Environment ("Zhou") | 2004 | Zhou; Elsevier B.V. | Addressed as appropriate |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| CU-SeeMe VR ("CU-SeeMe VR System") | Cornell University | A-15 |
| Wearable Spatial Conferencing Space with Virtual i-O iglasses ("Billinghurst System") | Billinghurst | A-14 |
| AAR system with MARA Headset ("Gamper AAR System") | Gamper/Columbia University | A-16 |
| Oculus Rift System | Oculus (now Meta) | Addressed as appropriate |
| VRChat | VRChat | Addressed as appropriate |
| SecondLife | Linden Lab | Addressed as appropriate |

### B. The '628 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claims of the '628 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 6,961,439 ("Ballas 439") | U.S. | Nov. 1, 2005 | B-01 |
| U.S. Patent No. 9,307,331 ("Pedersen") | U.S. | Apr. 5, 2016 | B-03 |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S Patent Pub. No. 2010/0328419 ("Etter 419") | U.S. | Dec. 30, 2010 | B-04 |
| U.S. Patent No. 8,406,439 ("Bedingfield") | U.S. | Mar. 26, 2013 | B-05 |
| U.S. Patent Pub. No. 2009/0052703 ("Hammershoi") | U.S. | Feb. 26, 2009 | B-06 |
| U.S. Patent No. 8,559,646 ("Gardner") | U.S. | Oct. 15, 2013 | B-08 |
| U.S. Patent No. 9,118,991 ("Nystrom") | U.S. | Aug. 25, 2015 | B-09 |
| U.S. Patent No. 6,882,971 ("Craner") | U.S. | Apr. 19, 2005 | B-10 |
| PCT Pub. No. WO 2013/49248 ("Haddick 248") | WO | Apr. 4, 2013 | B-11 |
| U.S. Patent No. 9,578,440 ("Otto 440") | U.S. | Feb. 21, 2017 | B-13 |
| PCT Pub. No. WO 2005/032209 ("Schroder") | TW | Sept. 15, 2004 | B-02 |
| U.S. Patent No. 8,797,386 ("Chou") | U.S. | Aug. 5, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 ("Flaks 968") | U.S. | July 1, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,520,872 ("Jang") | U.S. | Aug. 27, 2013 | Addressed as appropriate |
| U.S. Patent No. 8,818,000 ("Andrea") | U.S. | Aug. 26, 2014 | Addressed as appropriate |
| U.S. Patent No. 7,415,123 ("Ballas 123") | U.S. | Aug. 19, 2008 | Addressed as appropriate |
| U.S. Patent Pub. No. 2014/0064526 ("Otto 526") | U.S. | Mar. 6, 2014 | Addressed as appropriate |

| Publication Title | Date of Publication | Author and Publisher | Prior Art Type |
|---|---|---|---|
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | B-07 |
| A Wearable Spatial Conferencing Space ("Billinghurst 1998") | 1998 | Billinghurst; IEEE | Addressed as appropriate |
| Real-time Head-tracked 3D Audio with Unlimited Simultaneous Sounds ("Jin") | 2005 | Jin; ICAD | Addressed as appropriate |
| An Experimental Study on the Role of 3D Sound in Augmented Reality Environment ("Zhou") | 2004 | Zhou; Elsevier B.V. | Addressed as appropriate |



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| CU-SeeMe VR ("CU-SeeMe VR System") | Cornell University | B-14 |
| Wearable Spatial Conferencing Space with Virtual i-O iglasses ("Billinghurst System") | Billinghurst | B-12 |
| AAR system with MARA Headset ("Gamper AAR System") | Gamper/Columbia University | B-15 |
| Oculus Rift System | Oculus (now Meta) | Addressed as appropriate |
| VRChat | VRChat | Addressed as appropriate |
| SecondLife | Linden Lab | Addressed as appropriate |

### C. The '090 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one of more of the Asserted Claims of the '090 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 6,961,439 ("Ballas 439") | U.S. | Nov. 1, 2005 | C-01 |
| U.S. Patent No. 9,632,683 ("Jarvinen") | U.S. | Apr. 25, 2017 | C-02 |
| U.S. Patent No. 9,307,331 ("Pedersen") | U.S. | Apr. 5, 2016 | C-03 |
| U.S Patent Pub. No. 2010/0328419 ("Etter 419") | U.S. | Dec. 30, 2010 | C-04 |
| U.S. Patent No. 8,406,439 ("Bedingfield") | U.S. | Mar. 26, 2013 | C-05 |
| U.S. Patent Pub. No. 2009/0052703 ("Hammershoi") | U.S. | Feb. 26, 2009 | C-06 |
| U.S. Patent No. 9,961,208 ("Boustead") | U.S. | May 1, 2018 | C-08 |
| U.S. Patent No. 6,850,496 ("Knappe") | U.S. | Feb. 1, 2005 | C-09 |
| U.S. Patent No. 9,131,305 ("Li 305") | U.S. | Sept. 8, 2015 | C-10 |
| U.S. Patent No. 8,559,646 ("Gardner") | U.S. | Oct. 15, 2013 | C-11 |
| U.S. Patent No. 7,012,630 ("Curry") | U.S. | Mar. 14, 2006 | C-12 |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 8,818,000 ("Andrea") | U.S. | Aug. 26, 2014 | C-13 |
| U.S. Patent No. 8,797,386 ("Chou") | U.S. | Aug. 5, 2014 | Addressed as appropriate |
| U.S. Patent No. 9,578,440 ("Otto 440") | U.S. | Feb. 21, 2017 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 ("Flaks 968") | U.S. | July 1, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,520,872 ("Jang") | U.S. | Aug. 27, 2013 | Addressed as appropriate |
| U.S. Patent No. 7,415,123 ("Ballas 123") | U.S. | Aug. 19, 2008 | Addressed as appropriate |
| U.S. Patent Pub. No. 2014/0064526 ("Otto 526") | U.S. | Mar. 6, 2014 | Addressed as appropriate |

| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | C-07 |
| Multidimensional Audio Windows: Extending User Interfaces Through the Use of Spatial Auditory Information ("Cohen 1991 II") | 1991 | Cohen; Northwestern University | C-17 |
| A Wearable Spatial Conferencing Space ("Billinghurst 1998") | 1998 | Billinghurst; IEEE | Addressed as appropriate |
| Real-time Head-tracked 3D Audio with Unlimited Simultaneous Sounds ("Jin") | 2005 | Jin; ICAD | Addressed as appropriate |
| An Experimental Study on the Role of 3D Sound in Augmented Reality Environment ("Zhou") | 2004 | Zhou; Elsevier B.V. | Addressed as appropriate |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| CU-SeeMe VR ("CU-SeeMe VR System") | Cornell University | C-15 |
| Wearable Spatial Conferencing Space with Virtual i-O iglasses ("Billinghurst System") | Billinghurst | C-14 |
| AAR system with MARA Headset ("Gamper AAR System") | Gamper/Columbia University | C-16 |
| Oculus Rift System | Oculus (now Meta) | Addressed as appropriate |
| VRChat | VRChat | Addressed as appropriate |
| SecondLife | Linden Lab | Addressed as |



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| | | appropriate |

### D. The ’184 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claim of the ‘184 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 8,520,872 (“Jang”) | U.S. | Aug. 14, 2008 | D-01 |
| U.S. Patent No. 9,690,374 (“Clement”) | U.S. | Apr. 27, 2015 | D-02 |
| U.S. Patent Pub. No. 2016/0124502 (“Sawyer”) | U.S. | May 5, 2016 | D-03 |
| U.S. Patent No. 10,725,297 (“Kraver”) | U.S. | Jan. 28, 2015 | D-04 |
| U.K. Patent Pub. No. GB2524269A (“Ashforth”) | U.K. | Sept. 23, 2015 | D-05 |
| U.S. Patent No. 9,037,468 (“Osman”) | U.S. | May 19, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,140,554 (“Jerauld”) | U.S. | Jan 24, 3014 | Addressed as appropriate |
| U.S. Patent No. 9,612,722 (“Miller 722”) | U.S. | Oct. 31, 2014 | Addressed as appropriate |
| U.S. Patent No. 9,851,786 (“Pedrotti”) | U.S. | Dec. 10, 2014 | D-12 |
| U.S. Patent No. 9,041,622 (“McCulloch”) | U.S. | May 26, 2015 (issue) | Addressed as appropriate |
| U.S. Patent No. 9,078,076 (“Furse”) | U.S. | July 28, 2011 | Addressed as appropriate |
| U.S. Patent No. 10,113,877 (“Schaefer”) | U.S. | Sep. 11, 2015 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 (“Flaks 968”) | U.S. | Oct. 13, 2010 | Addressed as appropriate |
| U.S. Patent No. 9,787,846 (“Srinivasan”) | U.S. | Jan. 21, 2015 | Addressed as appropriate |
| U.S. Patent No. 7,876,903 (“Sauk 903”) | U.S. | Jul. 7, 2006 | Addressed as appropriate |



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| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| An Experimental Study on the Role of 3D Sound in Augmented Reality Environment ("Zhou") | 2004 | Zhou et al.; Interacting with Computers | D-06 |
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | Addressed as appropriate |
| Creating a Multi-Dimensional Communication Space to Improve the Effectiveness of 3-D Audio ("Sauk 2007") | 2007 | Sauk; IEEE | Addressed as appropriate |
| Real-time, Head-tracked 3D Audio with Unlimited Simultaneous Sounds ("Jin") | 2005 | Jin; ICAD | Addressed as appropriate |
| Techniques and Applications for Binaural Sound Manipulation in Human-Machine Interfaces ("Begault 1992") | 1992 | Begault; Int'l Journal of Aviation Psychology | Addressed as appropriate |
| Virtual Reality System with Integrated Sound Field Simulation and Reproduction ("Lentz") | 2007 | Lentz; EURASIP Journal on Advances in Signal Processing | Addressed as appropriate |
| Using 3D Sound for Providing 3D Interaction in Virtual Environment ("Ortega-Gonzalez") | 2010 | Ortega-Gonzalez; ASME | Addressed as appropriate |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| HTC Vive System ("HTC Vive System") | HTC | D-07 |
| NASA Virtual Interface Environment Workstation System ("NASA VIEW System") | NASA | D-08 |
| Oculus Rift System ("Oculus Rift System") | Oculus (now Meta) | D-09 |
| Sony Playstation VR System ("Sony PSVR System") | Sony | D-10 |
| Microsoft HoloLens System ("Microsoft HoloLens System") | Microsoft | D-11 |
| VRChat | VRChat | Addressed as appropriate |
| SecondLife | Linden Lab | Addressed as appropriate |
| AltSpaceVR | Microsoft | Addressed as appropriate |



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| CtrlAltStudio Viewer | David Rowe | Addressed as appropriate |

### E. The '179 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claim of the '179 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 9,690,374 ("Clement") | U.S. | April 27, 2015 | E-01 |
| U.K. Patent Pub. No. GB2524269A ("Ashforth") | U.K. | Sept. 23, 2015 | E-02 |
| U.S. Patent No. 8,520,872 ("Jang") | U.S. | Aug. 14, 2008 | E-03 |
| U.S. Patent Pub. No. 2016/0124502 ("Sawyer") | U.S. | Nov. 5, 2014 | E-04 |
| U.S. Patent No. 10,725,297 ("Kraver") | U.S. | Jan. 28, 2015 | E-05 |
| U.S. Patent No. 9,037,468 ("Osman") | U.S. | May 19, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,140,554 ("Jerauld") | U.S. | Jan 24, 3014 | Addressed as appropriate |
| U.S. Patent No. 9,612,722 ("Miller 722") | U.S. | Oct. 31, 2014 | Addressed as appropriate |
| U.S. Patent No. 9,851,786 ("Pedrotti") | U.S. | Dec. 10, 2014 | E-12 |
| U.S. Patent No. 9,041,622 ("McCulloch") | U.S. | May 26, 2015 (issue) | Addressed as appropriate |
| U.S. Patent No. 9,078,076 ("Furse") | U.S. | July 28, 2011 | Addressed as appropriate |
| U.S. Patent No. 10,113,877 ("Schaefer") | U.S. | Sep. 11, 2015 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 ("Flaks 968") | U.S. | Oct. 13, 2010 | Addressed as appropriate |
| U.S. Patent No. 9,787,846 ("Srinivasan") | U.S. | Jan. 21, 2015 | Addressed as appropriate |
| U.S. Patent No. 7,876,903 ("Sauk 903") | U.S. | Jul. 7, 2006 | Addressed as appropriate |



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| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| An Experimental Study on the Role of 3D Sound in Augmented Reality Environment ("Zhou") | 2004 | Zhou; Elsevier B.V. | E-06 |
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | Addressed as appropriate |
| Real-time, Head-tracked 3D Audio with Unlimited Simultaneous Sounds ("Jin") | 2005 | Jin; ICAD | Addressed as appropriate |
| Techniques and Applications for Binaural Sound Manipulation in Human-Machine Interfaces ("Begault 1992") | 1992 | Begault; Int'l Journal of Aviation Psychology | Addressed as appropriate |
| Virtual Reality System with Integrated Sound Field Simulation and Reproduction ("Lentz") | 2007 | Lentz; EURASIP Journal on Advances in Signal Processing | Addressed as appropriate |
| Using 3D Sound for Providing 3D Interaction in Virtual Environment ("Ortega-Gonzalez") | 2010 | Ortega-Gonzalez; ASME | Addressed as appropriate |
| Creating a Multi-Dimensional Communication Space to Improve the Effectiveness of 3-D Audio ("Sauk 2007") | 2007 | Sauk; IEEE | Addressed as appropriate |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| HTC Vive System ("HTC Vive System") | HTC | E-07 |
| NASA Virtual Interface Environment Workstation System ("NASA VIEW System") | NASA | E-08 |
| Oculus Rift System ("Oculus Rift System") | Oculus (now Meta) | E-09 |
| Sony Playstation VR System ("Sony PSVR System") | Sony | E-10 |
| Microsoft HoloLens System ("Microsoft HoloLens System") | Microsoft | E-11 |
| VRChat | VRChat | Addressed as appropriate |
| SecondLife | Linden Lab | Addressed as appropriate |
| AltSpaceVR | Microsoft | Addressed as appropriate |
| CtrlAltStudio Viewer | David Rowe | Addressed as |



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| | | appropriate |

### F. The ’737 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claims of the ’737 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 9,037,468 (“Osman”) | U.S. | May 19, 2015 | F-01 |
| U.S. Patent Pub. No. 2016/0124502 (“Sawyer”) | U.S. | Nov. 5, 2014 | F-02 |
| U.S. Patent Pub. No. 2015/0119130 (“Lovitt”) | U.S. | Apr. 30, 2015 | F-03 |
| U.S. Patent No. 10,095,031 (“Katz 031”) | U.S. | Jan. 1, 2016 | F-04 |
| U.K. Patent Pub. No. GB2524269A (“Ashforth”) | G.B. | Sept. 23, 2015 | F-05 |
| U.S. Patent Pub. No. 2016/0292924 (“Balachandreswaran”) | U.S. | Oct. 31, 2012 | F-06 |
| U.S. Patent No. 9,851,786 (“Pedrotti”) | U.S. | July 7, 2015 | F-07 |
| U.S. Patent No. 9,041,622 (“McCulloch”) | U.S. | May 26, 2015 | F-08 |
| U.S. Patent Pub. No. 2014/0002444 (“Bennett”) | U.S. | Jan. 2, 2014 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0026253 (“Bradski 253”) | U.S. | Jan. 28, 2016 | Addressed as appropriate |
| U.S. Patent No. 9,860,666 (“Laitinen”) | U.S. | June 18, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,897,805 (“Stafford 805”) | U.S. | June 7, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0124707 (“Ermilov”) | U.S. | Oct. 31, 2014 | Addressed as appropriate |
| U.S. Patent No. 5,900,849 (“Gallery”) | U.S. | May 4, 1999 | Addressed as appropriate |
| U.S. Patent No. 9,767,618 (“Najaf-Zadeh”) | U.S. | Jan. 28, 2015 | Addressed as appropriate |
| U.S. Patent Pub. No. 2007/0173265 (“Gum”) | U.S. | July 26, 2007 | Addressed as appropriate |
| U.S. Patent No. 10,191,561 (“Katz | U.S. | June 15, 2015 | Addressed as |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| 561") | | | appropriate |
| U.S. Patent Pub. No. US 2013/0084970 ("Geisner") | U.S. | April 4, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. US 2015/0156592 ("Jensen") | U.S. | June 4, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,933,989 ("Tsingos 989") | U.S. | Oct. 31, 2013 | Addressed as appropriate |
| U.S. Patent No. 7,936,887 ("Smyth") | U.S. | May 3, 2011 | Addressed as appropriate |
| U.S. Patent No. 9,787,846 ("Srinivasan") | U.S. | Jan. 21, 2015 | Addressed as appropriate |
| U.S. Patent No. 10,509,466 ("Miller 466") | U.S. | May 11, 2011 | Addressed as appropriate |
| EP1538512 A3 ("Toshikazu") | Japan | Oct. 27, 2010 | Addressed as appropriate |
| U.S. Patent Pub. No. 2014/0125698 ("Latta") | U.S. | May 8, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,744,113 ("Rickards") | U.S. | June 3, 2014 | Addressed as appropriate |
| U.S. Patent Pub. No. 2015/0348327 ("Zalewski 327") | U.S. | Dec. 3, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,560,467 ("Gorzel") | U.S. | Nov. 11, 2014 | Addressed as appropriate |
| U.S. Patent No. 10,114,465 ("Wan") | U.S. | Jan. 15, 2016 | Addressed as appropriate |
| U.S. Patent Pub. No. 2017/0078825 ("Mangiat") | U.S. | Sept. 16, 2015 | Addressed as appropriate |
| U.S. Patent No. 11,163,358 ("Marks") | U.S. | Mar. 17, 2016 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 ("Flaks 968") | U.S. | Oct. 13, 2010 | Addressed as appropriate |

| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | F-14 |
| Augmented Reality Audio for Mobile and Wearable Appliances ("Harma") | 2004 | Harma; Journal of The Audio Engineering Society | Addressed as appropriate |



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| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| Virtual Reality System with Integrated Sound Field Simulation and Reproduction ("Lentz") | 2007 | Lentz; EURASIP Journal on Advances in Signal Processing | Addressed as appropriate |
| The VR Book: Human-Centered Design for Virtual Reality ("Jerald")[2] | 2015 | Jerald; Morgan & Claypool | Addressed as appropriate |
| 3D Audio Interface for Rich Mobile Web Experiences ("Wu") | 2012 | Wu; International Conference on Mobile Computing, Applications, and Services | F-13 |
| Interactive Virtual Soundscapes: A Research Report ("Camci 2015") | 2015 | Camci; International Computer Music Conference | Addressed as appropriate |
| Integrating Graphic and Audio Windows ("Cohen 1993 I") | 1993 | Cohen; Presence, The Massachusetts Institute of Technology | Addressed as appropriate |
| Multidimensional Audio Windows: Extending User Interfaces Through the Use of Spatial Auditory Information ("Cohen 1991 II") | 1991 | Cohen; Northwestern University | Addressed as appropriate |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| Sony Playstation VR System ("Sony PSVR System") | Sony | F-09 |
| HTC Vive System ("HTC Vive System") | HTC | F-10 |
| Oculus Rift System ("Oculus Rift System") | Oculus (now Meta) | F-11 |
| Microsoft HoloLens System ("Microsoft HoloLens System") | Microsoft | F-12 |

[2] Defendants reserve the right to rely on all prior art editions of this textbook, including the first edition, e.g., *The VR Book: Perception and Interaction Design for Virtual Reality*, and disclosures in such other editions that are analogous to those cited in these contentions.



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| Oculus Spatializer Plug-in for Unity | Oculus (now Meta) | Addressed as appropriate |
| Audio Spatializer SDK (Unity 5.3) | Unity | Addressed as appropriate |
| Cardboard (including SDK for Unity and Android) | Google | Addressed as appropriate |
| HeadZap | AuSIM | Addressed as appropriate |
| RealSpace3D Audio Unity Plugin Beta Version | VisiSonics | Addressed as appropriate |
| VRChat | VRChat | Addressed as appropriate |
| Second Life | Linden Lab | Addressed as appropriate |
| Project Sansar | Linden Lab | Addressed as appropriate |
| AltSpaceVR | Microsoft | Addressed as appropriate |
| CtrlAltStudio Viewer | David Rowe | Addressed as appropriate |

### G. The ’509 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claims of the ’509 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 9,037,468 (“Osman”) | U.S. | May 19, 2015 | G-01 |
| U.S. Patent Pub. No. 2016/0124502 (“Sawyer”) | U.S. | Nov. 5, 2014 | G-02 |
| U.S. Patent Pub. No. 2015/0119130 (“Lovitt”) | U.S. | Apr. 30, 2015 | G-03 |
| U.S. Patent No. 10,095,031 (“Katz 031”) | U.S. | Jan. 1, 2016 | G-04 |
| U.K. Patent Pub. No. GB2524269A (“Ashforth”) | G.B. | Sept. 23, 2015 | G-05 |
| U.S. Patent Pub. No. 2016/0292924 (“Balachandreswaran”) | U.S. | Oct. 31, 2012 | G-06 |
| U.S. Patent No. 9,851,786 (“Pedrotti”) | U.S. | July 7, 2015 | G-07 |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 9,041,622 ("McCulloch") | U.S. | May 26, 2015 | G-08 |
| U.S. Patent Pub. No. 2014/0002444 ("Bennett") | U.S. | Jan. 2, 2014 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0026253 ("Bradski 253") | U.S. | Jan. 28, 2016 | Addressed as appropriate |
| U.S. Patent No. 9,860,666 ("Laitinen") | U.S. | June 18, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,897,805 ("Stafford 805") | U.S. | June 7, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0124707 ("Ermilov") | U.S. | Oct. 31, 2014 | Addressed as appropriate |
| U.S. Patent No. 5,900,849 ("Gallery") | U.S. | May 4, 1999 | Addressed as appropriate |
| U.S. Patent No. 9,767,618 ("Najaf-Zadeh") | U.S. | Jan. 28, 2015 | Addressed as appropriate |
| U.S. Patent Pub. No. 2007/0173265 ("Gum") | U.S. | July 26, 2007 | Addressed as appropriate |
| U.S. Patent No. 10,191,561 ("Katz 561") | U.S. | June 15, 2015 | Addressed as appropriate |
| U.S. Patent Pub. No. US 2013/0084970 ("Geisner") | U.S. | April 4, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. US 2015/0156592 ("Jensen") | U.S. | June 4, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,933,989 ("Tsingos 989") | U.S. | Oct. 31, 2013 | Addressed as appropriate |
| U.S. Patent No. 7,936,887 ("Smyth") | U.S. | May 3, 2011 | Addressed as appropriate |
| U.S. Patent No. 9,787,846 ("Srinivasan") | U.S. | Jan. 21, 2015 | Addressed as appropriate |
| U.S. Patent No. 10,509,466 ("Miller 466") | U.S. | May 11, 2011 | Addressed as appropriate |
| EP1538512 A3 ("Toshikazu") | Japan | Oct. 27, 2010 | Addressed as appropriate |
| U.S. Patent Pub. No. 2014/0125698 ("Latta") | U.S. | May 8, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,744,113 ("Rickards") | U.S. | June 3, 2014 | Addressed as appropriate |
| U.S. Patent Pub. No. 2015/0348327 ("Zalewski 327") | U.S. | Dec. 3, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,560,467 ("Gorzel") | U.S. | Nov. 11, 2014 | Addressed as appropriate |
| U.S. Patent No. 10,114,465 ("Wan") | U.S. | Jan. 15, 2016 | Addressed as appropriate |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent Pub. No. 2017/0078825 ("Mangiat") | U.S. | Sept. 16, 2015 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 ("Flaks 968") | U.S. | Oct. 13, 2010 | Addressed as appropriate |

| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| 3-D Sound for Virtual Reality and Multimedia ("Begault 2000") | 2000 | Begault; NASA | G-14 |
| Augmented Reality Audio for Mobile and Wearable Appliances ("Harma") | 2004 | Harma; Journal of The Audio Engineering Society | Addressed as appropriate |
| Virtual Reality System with Integrated Sound Field Simulation and Reproduction ("Lentz") | 2007 | Lentz; EURASIP Journal on Advances in Signal Processing | Addressed as appropriate |
| The VR Book: Human-Centered Design for Virtual Reality ("Jerald") | 2015 | Jerald; Morgan & Claypool | Addressed as appropriate |
| 3D Audio Interface for Rich Mobile Web Experiences ("Wu") | 2012 | Wu; International Conference on Mobile Computing, Applications, and Services | G-13 |
| Interactive Virtual Soundscapes: A Research Report ("Camci 2015") | 2015 | Camci; International Computer Music Conference | Addressed as appropriate |
| Integrating Graphic and Audio Windows ("Cohen 1993 I") | 1993 | Cohen; Presence, The Massachusetts Institute of Technology | Addressed as appropriate |
| Multidimensional Audio Windows: Extending User Interfaces Through the Use of Spatial Auditory Information ("Cohen 1991 II") | 1991 | Cohen; Northwestern University | Addressed as appropriate |



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| Sony Playstation VR System ("Sony PSVR System") | Sony | G-09 |
| HTC Vive System ("HTC Vive System") | HTC | G-10 |
| Oculus Rift System ("Oculus Rift System") | Oculus (now Meta) | G-11 |
| Microsoft HoloLens System ("Microsoft HoloLens System") | Microsoft | G-12 |
| Oculus Spatializer plug-in for Unity | Oculus (now Meta) | Addressed as appropriate |
| Audio Spatializer SDK (Unity 5.3) | Unity | Addressed as appropriate |
| Cardboard (including SDK for Unity and Android) | Google | Addressed as appropriate |
| HeadZap | AuSIM | Addressed as appropriate |
| RealSpace3D Audio Unity Plugin Beta Version | VisiSonics | Addressed as appropriate |
| VRChat | VRChat | Addressed as appropriate |
| Second Life | Linden Lab | Addressed as appropriate |
| Project Sansar | Linden Lab | Addressed as appropriate |
| AltSpaceVR | Microsoft | Addressed as appropriate |
| CtrlAltStudio Viewer | David Rowe | Addressed as appropriate |

### H. The '316 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claims of the '316 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 9,037,468 ("Osman") | U.S. | May 19, 2015 | H-01 |
| U.S. Patent Pub. No. 2016/0124502 ("Sawyer") | U.S. | Nov. 5, 2014 | H-02 |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent Pub. No. 2015/0119130 ("Lovitt") | U.S. | Apr. 30, 2015 | H-03 |
| U.S. Patent No. 10,095,031 ("Katz 031") | U.S. | Jan. 1, 2016 | H-04 |
| U.K. Patent Pub. No. GB2524269A ("Ashforth") | G.B. | Sept. 23, 2015 | H-05 |
| U.S. Patent Pub. No. 2016/0292924 ("Balachandreswaran") | U.S. | Oct. 31, 2012 | H-06 |
| U.S. Patent No. 9,851,786 ("Pedrotti") | U.S. | July 7, 2015 | H-07 |
| U.S. Patent No. 9,041,622 ("McCulloch") | U.S. | May 26, 2015 | H-08 |
| U.S. Patent Pub. No. 2014/0002444 ("Bennett") | U.S. | Jan. 2, 2014 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0026253 ("Bradski 253") | U.S. | Jan. 28, 2016 | Addressed as appropriate |
| U.S. Patent No. 9,860,666 ("Laitinen") | U.S. | June 18, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,897,805 ("Stafford 805") | U.S. | June 7, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0124707 ("Ermilov") | U.S. | Oct. 31, 2014 | Addressed as appropriate |
| U.S. Patent No. 5,900,849 ("Gallery") | U.S. | May 4, 1999 | Addressed as appropriate |
| U.S. Patent No. 9,767,618 ("Najaf-Zadeh") | U.S. | Jan. 28, 2015 | Addressed as appropriate |
| U.S. Patent Pub. No. 2007/0173265 ("Gum") | U.S. | July 26, 2007 | Addressed as appropriate |
| U.S. Patent No. 10,191,561 ("Katz 561") | U.S. | June 15, 2015 | Addressed as appropriate |
| U.S. Patent Pub. No. US 2013/0084970 ("Geisner") | U.S. | April 4, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. US 2015/0156592 ("Jensen") | U.S. | June 4, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,933,989 ("Tsingos 989") | U.S. | Oct. 31, 2013 | Addressed as appropriate |
| U.S. Patent No. 7,936,887 ("Smyth") | U.S. | May 3, 2011 | Addressed as appropriate |
| U.S. Patent No. 9,787,846 ("Srinivasan") | U.S. | Jan. 21, 2015 | Addressed as appropriate |
| U.S. Patent No. 10,509,466 ("Miller 466") | U.S. | May 11, 2011 | Addressed as appropriate |
| EP1538512 A3 ("Toshikazu") | Japan | Oct. 27, 2010 | Addressed as appropriate |



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| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent Pub. No. 2014/0125698 ("Latta") | U.S. | May 8, 2014 | Addressed as appropriate |
| U.S. Patent No. 8,744,113 ("Rickards") | U.S. | June 3, 2014 | Addressed as appropriate |
| U.S. Patent Pub. No. 2015/0348327 ("Zalewski 327") | U.S. | Dec. 3, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,560,467 ("Gorzel") | U.S. | Nov. 11, 2014 | Addressed as appropriate |
| U.S. Patent No. 10,114,465 ("Wan") | U.S. | Jan. 15, 2016 | Addressed as appropriate |
| U.S. Patent Pub. No. 2017/0078825 ("Mangiat") | U.S. | Sept. 16, 2015 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 ("Flaks 968") | U.S. | Oct. 13, 2010 | Addressed as appropriate |

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| Augmented Reality Audio for Mobile and Wearable Appliances ("Harma") | 2004 | Harma; Journal of The Audio Engineering Society | Addressed as appropriate |
| Virtual Reality System with Integrated Sound Field Simulation and Reproduction ("Lentz") | 2007 | Lentz; EURASIP Journal on Advances in Signal Processing | Addressed as appropriate |
| The VR Book: Human-Centered Design for Virtual Reality ("Jerald") | 2015 | Jerald; Morgan & Claypool | Addressed as appropriate |
| 3D Audio Interface for Rich Mobile Web Experiences ("Wu") | 2012 | Wu; International Conference on Mobile Computing, Applications, and Services | H-13 |



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| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| Interactive Virtual Soundscapes: A Research Report ("Camci 2015") | 2015 | Camci; International Computer Music Conference | Addressed as appropriate |
| Integrating Graphic and Audio Windows ("Cohen 1993 I") | 1993 | Cohen; Presence, Massachusetts Institute of Technology | Addressed as appropriate |
| Multidimensional Audio Windows: Extending User Interfaces Through the Use of Spatial Auditory Information ("Cohen 1991 II") | 1991 | Cohen; Northwestern University | Addressed as appropriate |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| Sony Playstation VR System ("Sony PSVR System") | Sony | H-09 |
| HTC Vive System ("HTC Vive System") | HTC | H-10 |
| Oculus Rift System ("Oculus Rift System") | Oculus (now Meta) | H-11 |
| Microsoft HoloLens System ("Microsoft HoloLens System") | Microsoft | H-12 |
| Oculus Spatializer plug-in for Unity | Oculus (now Meta) | Addressed as appropriate |
| Audio Spatializer SDK (Unity 5.3) | Unity | Addressed as appropriate |
| Cardboard (including SDK for Unity and Android) | Google | Addressed as appropriate |
| HeadZap | AuSIM | Addressed as appropriate |
| RealSpace3D Audio Unity Plugin Beta Version | VisiSonics | Addressed as appropriate |
| VRChat | VRChat | Addressed as appropriate |
| Second Life | Linden Lab | Addressed as appropriate |
| Project Sansar | Linden Lab | Addressed as appropriate |
| AltSpaceVR | Microsoft | Addressed as appropriate |
| CtrlAltStudio Viewer | David Rowe | Addressed as appropriate |



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## I. The ’836 Patent

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, anticipate and/or render obvious one or more of the Asserted Claims of the ’836 Patent:

| Patent/Publication Number | Country of Origin | Date of Prior Art | Exhibit |
|---|---|---|---|
| U.S. Patent No. 9,037,468 (“Osman”) | U.S. | May 19, 2015 | I-01 |
| U.S. Patent No. 10,979,843 (“Shivappa 843”) | U.S. | April 8, 2016 | I-02 |
| U.S. Patent No. 10,089,063 (“Shivappa 063”) | U.S. | Aug. 10, 2016 | I-03 |
| U.S. Patent No. 9,226,090 (“Norris 090”) | U.S. | Dec. 29, 2015 | I-04 |
| U.S. Patent Pub. No. 2016/0124707 (“Ermilov”) | U.S. | Oct. 31, 2014 | I-05 |
| U.S. Patent No. 9,530,426 (“Wright”) | U.S. | June 24, 2015 | I-06 |
| U.S. Patent No. 8,587,631 (“Etter 631”) | U.S. | June, 29, 2010 | I-07 |
| U.S. Patent No. 9,860,666 (“Laitinen”) | U.S. | June 18, 2015 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0088417 (“Kim 417”) | U.S. | June 5, 2013 | Addressed as appropriate |
| U.S. Patent Pub. No. 2015/0119130 (“Lovitt”) | U.S. | Apr. 30, 2015 | Addressed as appropriate |
| U.S. Patent No. 9,041,622 (“McCulloch”) | U.S. | May 26, 2015 | Addressed as appropriate |
| U.S. Patent No. 8,767,968 (“Flaks 968”) | U.S. | October 13, 2010 | Addressed as appropriate |
| U.S. Patent Pub. No. 2016/0026253 (“Bradski 253”) | U.S. | Jan. 28, 2016 | Addressed as appropriate |
| U.S. Patent No. 9,131,305 (“Li 305”) | U.S. | Jan 17, 2013 | Addressed as appropriate |

| Publication Title | Date of Publication | Author and Publisher | Exhibit |
|---|---|---|---|
| 3-D Sound for Virtual Reality and Multimedia (“Begault 2000”) | 2000 | Begault; NASA | I-08 |



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| | | | |
|---|---|---|---|
| Headphone-Based Spatial Sound ("Algazi 2011") | January 2011 | Algazi: IEEE Signal Processing Magazine | I-09 |
| The VR Book: Human-Centered Design for Virtual Reality ("Jerald") | 2015 | Jerald; Morgan & Claypool | Addressed as appropriate |
| The CIPIC HRTF Database ("Algazi 2001") | 2001 | Algazi; IEEE Workshop on Applications of Signal Processing to Audio and Acoustics | Addressed as appropriate |
| Insights into head-related transfer function: Spatial dimensionality and continuous representation ("Zhang") | 2010 | Zhang; The Journal of the Acoustical Society of America | Addressed as appropriate |
| Near-Field Compensation for HRTF Processing ("Romblom") | October 2008 | Romblom; Audio Engineering Society | Addressed as appropriate |
| Near-Field Virtual Audio Displays ("Brungart") | February 2002 | Brungart; Presence | Addressed as appropriate |
| HRTF Measurements of a KEMAR Dummy-Head Microphone ("Garner 1994") | May 1994 | Gardner; MIT Media Lab Perceptual Computing | Addressed as appropriate |
| The SoundScape Renderer: A Unified Spatial Audio Reproduction Framework for Arbitrary Rendering Methods ("Ahrens") | May 2008 | Ahrens; Journal of The Audio Engineering Society | Addressed as appropriate |
| Compensating for distance compression in virtual audiovisual environments using incongruence ("Finnegan") | 2016 | Finnegan; Association for Computing Machinery | I-13 |

| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| Sony Playstation VR System ("Sony PSVR System") | Sony | I-10 |
| HTC Vive System ("HTC Vive System") | HTC | I-11 |
| Oculus Rift System ("Oculus Rift | Oculus (now Meta) | I-12 |



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| Product or Use | Person or Entity | Exhibit |
|---|---|---|
| System") | | |
| Oculus Spatializer Plug-in for Unity | Oculus (now Meta) | Addressed as appropriate |
| Audio Spatializer SDK (Unity 5.3) | Unity | Addressed as appropriate |
| Cardboard (including SDK for Unity and Android) | Google | Addressed as appropriate |

### J. Additional References Relevant To State Of The Art

The following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references, also are pertinent to the invalidity of the Asserted Claims, including with respect to the state of the art and the level of knowledge of a POSA as of the Asserted Claims' purported priority dates (and dates thereafter).

| Patent/Publication Number | Country of Origin | Date of Prior Art |
|---|---|---|
| CN105872444 ("Du") | China | Apr. 22, 2016 (appl.) |
| DE102006018490B4 ("Wolfgang") (with translation) | Germany | May 8, 2008 |
| EP1617702 ("Sundstrom") | E.U. | Sept. 8, 2010 |
| EP1843627 ("Peng") | E.U. | Dec. 19, 2006 (appl.) |
| EP2160005 ("British Telecom") | E.U. | Mar. 3, 2010 |
| EP2373055 ("Lindau") | E.U. | June 7, 2006 |
| GB2382288A ("Belrose") | U.K. | Jan. 5, 2005 |
| GB2384413B ("Nelson") | U.K. | Jan. 5, 2005 |
| JPH1023600 ("Sekine") (with translation) | Japan | Mar. 1, 2006 |
| JP2014093698A ("Yamanaka") | Japan | Nov. 5, 2012 (appl.) |
| JP2015233284A ("Matsuda") | Japan | Jun. 10, 2015 (appl.) |
| JP3435141B2 ("Kazuhiro") | Japan | Aug. 11, 2003 |
| JPH08315175 ("Okada") (with translation) | Japan | Oct. 13, 2004 |
| KR101103361B1 ("Young-Jin") | Korea | Jan. 5, 2012 |
| KR101408921B1 ("Woo") | Korea | Feb. 4, 2008 |
| KR20040048104A ("Choi 104") (with translation) | Korea | June 7, 2004 |
| KR20100052752A ("Park 752") (with translation) | Korea | May 20, 2010 |
| KR20070000113A ("Kim 113") (with translation) | Korea | Jan. 2, 2007 |
| KR20140129654A ("Kim 654") (with translation) | Korea | Apr. 30, 2013 |



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| Patent/Publication Number | Country of Origin | Date of Prior Art |
|---|---|---|
| | | (appl.) |
| KR20170041323A ("Kim 323") (with translation) | Korea | Oct. 6, 2015 (appl.) |
| PCT Pub. No. WO 2006/076926A2 ("Pedersen 926") | PCT | July 27, 2006 |
| PCT Pub. No. WO 2009/106916A1 ("Elg 916") | PCT | Sept. 3, 2009 |
| PCT Pub. No. WO 2010/075481A1 ("Taranas") | PCT | July 1, 2010 |
| PCT Pub. No. WO 2010/086321A1 ("Portas Arrondo") | PCT | Aug. 5, 2010 |
| PCT Pub. No. WO 2011/109126A1 ("Weising") | PCT | Sept. 9, 2011 |
| PCT Pub. No. WO 2012/164153A1 ("Shenoy") | PCT | Dec. 6, 2012 |
| PCT Pub. No. WO 2013/049248A2 ("Haddick") | PCT | Apr. 4, 2013 |
| PCT Pub. No. WO 2013/064914A1 ("Ek") | PCT | May 10, 2013 |
| PCT Pub. No. WO 2014/069776A1 ("Cho") | PCT | May 8, 2014 |
| PCT Pub. No. WO 2014/079578A1 ("Perrodin") | PCT | Nov. 22, 2013 (appl.) |
| PCT Pub. No. WO 2014/178480A1 ("Kim 480") (with translation) | PCT | June 5, 2013 (appl.) |
| PCT Pub. No. WO 2015/034453A1 ("Latypov 453") | PCT | Sept. 6, 2013 (appl.) |
| PCT Pub. No. WO 2015/047775A1 ("Stafford 775") | PCT | Sept. 15, 2014 (appl.) |
| PCT Pub. No. WO 2015/188011A1 ("Chandler") | PCT | June 4, 2015 (appl.) |
| PCT Pub. No. WO 2016/064435A1 ("Fei") | PCT | Oct. 23, 2015 (appl.) |
| TWM431354U (“Wu”) | Taiwan | June 11, 2012 |
| U.S. Patent No. 10,013,808 ("Jones") | U.S. | Feb. 2, 2016 (appl.) |
| U.S. Patent No. 10,026,232 ("Lo") | U.S. | Jan. 4, 2017 (appl.) |
| U.S. Patent No. 10,048,835 ("Cotier") | U.S. | Apr. 19, 2015 (appl.) |
| U.S. Patent No. 10,070,239 ("Romigh 239") | U.S. | Feb. 16, 2017 (appl.) |
| U.S. Patent No. 10,101,961 ("Gao") | U.S. | Dec. 21, 2015 (appl.) |
| U.S. Patent No. 10,111,013 ("Hu") | U.S. | Jan. 24, 2014 (appl.) |
| U.S. Patent No. 10,130,873 ("Kim 873") | U.S. | Mar. 17, 2015 (appl.) |
| U.S. Patent No. 10,142,755 ("Boland") | U.S. | Feb. 7, 2017 (appl.) |
| U.S. Patent No. 10,158,963 ("Brettle") | U.S. | Jan. 30, 2017 (appl.) |



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| Patent/Publication Number | Country of Origin | Date of Prior Art |
|---|---|---|
| U.S. Patent No. 10,171,928 ("Nair") | U.S. | Aug. 9, 2016 (appl.) |
| U.S. Patent No. 10,203,762 ("Bradski 762") | U.S. | June 13, 2015 (appl.) |
| U.S. Patent No. 10,219,013 ("Luna") | U.S. | Dec. 24, 2014 (appl.) |
| U.S. Patent No. 10,231,056 ("Poornachandran") | U.S. | Dec. 27, 2014 (appl.) |
| U.S. Patent No. 10,231,073 ("Stein") | U.S. | June 16, 2017 (appl.) |
| U.S. Patent No. 10,235,567 ("Cork") | U.S. | May 13, 2014 (appl.) |
| U.S. Patent No. 10,251,012 ("Schnaefer") | U.S. | June 5, 2017 (appl.) |
| U.S. Patent No. 10,320,437 ("Fei 437") | U.S. | Mar. 3, 2016 (appl.) |
| U.S. Patent No. 10,354,446 ("Jagnow") | U.S. | Apr. 13, 2016 (appl.) |
| U.S. Patent No. 10,488,919 ("George-Svahn") | U.S. | Dec. 31, 2015 (appl.) |
| U.S. Patent No. 10,492,019 ("Briggs") | U.S. | Feb. 27, 2017 (appl.) |
| U.S. Patent No. 10,506,067 ("Lederman") | U.S. | Mar. 15, 2013 (appl.) |
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|---|---|---|
| Controlling and Filtering Information Density with Spatial Interaction Techniques via Handheld Augmented Reality ("Keil") | 2013 | Keil; Virtual Augmented and Mixed Reality. Designing and Developing Augmented and Virtual Environments 2013 |
| Creation of a System for Real Time Virtual Auditory Space and Its Application to Dynamic Sound Localization ("Scarpaci 2006") | 2006 | Scarpaci; Boston University |
| Customizable Auditory Displays ("Zotkin 2002") | 2002 | Zotkin; ICAD |
| Customized 3D sound for innovative interaction design ("Geronazzo") | 2011 | Geronazzo; Proc. Italian ACM SigCHI Conf. on Computer-Human Interaction |
| Designing and Controlling Virtual Sonic Environments Using a Browser-based 3DUI ("Çamcı") | 2016 | Çamcı; University of Illinois at Chicago, Electronic Visualization Laboratory |
| Development and Evaluation of Augmented Reality Audio Systems ("Tikander") | 2009 | Tikander; Helsinki University of Technology |
| Development of Hardware and Software for a game-like Wireless Spatial Sound Distribution System ("Dharmadhikari") | 2016 | Dharmadhikari; Arizona State University |
| Direct Comparison of the Impact of Head Tracking, Reverberation, and Individualized Head-Related Transfer Functions on the Spatial Perception of a Virtual Speech Source ("Begault 2001") | 2001 | Begault; NASA |
| DIVA Virtual Audio Reality System ("Huopaniemi") | 1996 | Huopaniemi; ICAD |
| Effect of Increasing System Latency on Localization of Virtual Sounds ("Wenzel 2001") | 2001 | Wenzel; ICAD |
| Effects of Localized Auditory Information on Visual Target Detection Performance Using a Helmet Mounted Display ("Nelson") | 1998 | Nelson; Human Factors |
| Efficient Models for Reverberation and Distance Rendering in Computer Music and Virtual Audio Reality ("Jot") | 1997 | Jot; ICMC97 |
| Enhancing Three-dimensional Vision with Three-dimensional Sound ("Dobler") | 2004 | Dobler; SIGGRAPH; AUDITE |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| Evaluation of a Low-Cost 3D Sound System for Immersive Virtual Reality Training Systems ("Doerr 2007") | 2007 | Doerr; IEEE Transactions on Visualization and Computer Graphics |
| Exclude and Include for Audio Sources and Sinks: Analogs of Mute & Solo Are Deafen & Attend ("Cohen 2000") | 2000 | Cohen; Massachusetts Institute of Technology |
| Experiments in Spatal Mobile Audio-Conferencing ("Deo") | 2007 | Deo; Association for Computing Machinery |
| Exploring Large Virtual Environments with an HMD when Physical Space is Limited ("Williams") | 2007 | Williams; Association for Computing Machinery |
| Extending the Notion of a Window System to Audio ("Ludwig") | 1990 | Ludwig; IEEE |
| Externalization Improvement in a Real-time Binaural Sound Image Rendering System ("Yuan") | 2015 | Yuan; ICOT 2015 |
| Fluid Interaction in Audio-Guided Museum Visit: Authoring Tool and Visitor Device ("Kaghat") | 2010 | Kaghat; 11th International Symposium on Virtual Reality, Archaeology and Cultural Heritage |
| For VR truly immersive, it needs convincing sound to match ("Lalwani") | 2016 | Lalwani; Engadget |
| Game Sound Technology and Player Interaction: Concepts and Developments ("Grimshaw") | 2011 | Grimshaw; IGI Global |
| Headphone Simulation of Free-Field Listening. I: Stimulus Synthesis ("Wightman I 1998") | 1988 | Wightman; Acoustical Society of America |
| Headphone Simulation of Free-Field Listening. II: Psychophysical Validation ("Wightman II 1998") | 1988 | Wightman; Acoustical Society of America |
| Head-Related Transfer Functions and Virtual Auditory Display ("Zhong") | 2014 | Zhong; IntechOpen |
| High Order Spatial Audio Capture and its Binaural Head-Tracked Playback over Headphones with HRTF Cues ("Duraiswami 2005 I") | 2005 | Duraiswami; Audio Engineering Socierty |
| Highly Realistic Audio Spatialization for Multiparty Conferencing Using Headphones ("Chen 2009") | 2009 | Chen; IEEE International Workshop on Multimedia Signal Processing |
| High-Performance Wide-Area Optical Tracking ("Welch 2001") | 2001 | Welch; Massachusetts Institute of Technology |
| Huron - A Digital Audio Convolution Workstation ("McGrath 1995") | 1995 | McGrath; Audio Engineering Society |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| I Hear NY4D: Hybrid Acoustic and Augmented Auditory Display for Urban Soundscapes ("Boren") | 2014 | Boren; ICAD |
| iEAR: Immersive Environmental Audio for Photorealistic Panoramas ("Riker") | 2014 | Riker; ICAD |
| Image Projection in Immersive 3D Visualization Laboratory ("Mazikowski") | 2014 | Mazikowski; Procedia Computer Science |
| iMedic: A Two-Handed Immersive Medical Environment for Distributed Interactive Consultation ("Mlyniec") | 2011 | Mlyniec; Studies in Health Technology and Informatics |
| Immersive Audio for VR ("Altman") | 2016 | Altman; Audio Engineering Society |
| Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio, Chapter 1: Perception of Spatial Sound ("Wenzel 2017") | 2017 | Wenzel; Audio Engineering Society |
| Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio, Chapter 8: Object-Based Audio ("Tsingos 2017") | 2017 | Tsingos; Audio Engineering Society |
| Immersive Sound: The Art and Science of Binaural and Multi-Channel Audio, Chapter 9: Sound Field ("Nicol") | 2017 | Nicol; Audio Engineering Society |
| Influence of Head Tracking on the Externalization of Speech Stimuli for Non-Individualized Binaural Synthesis ("Hendricx") | 2017 | Hendrickx; Acoustical Society of America |
| Integrating Real-time Binaural Acoustics into VR Applications ("Assenmacher") | 2004 | Assenmacher; Eurographics Symposium on Virtual Environments |
| Integration of the Rugers Master II in a Virtual Reality Simulation ("Gomez") | 1995 | Gomez; IEEE Computer Society |
| Interacting with Sound: An Interaction Paradigm for Virtual Auditory Worlds ("Rober 2004") | 2004 | Rober; ICAD |
| Interactive Soundscapes in Mobile Contexts ("Marques") | 2016 | Marques; University of Coimbra |
| Leaving the Screen New Perspectives in Audio-only Gaming ("Rober 2005") | 2005 | Rober; ICAD |
| Listening Tests and Evaluation of Simulated Sound Fields Using a VibeStudio Designer ("Wersenyi") | 2010 | Wersenyi; ICAD |
| Localization in Virtual Acoustic Displays ("Wenzel 1992") | 1992 | Wenzel; Presence |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| Localization of Virtual Sound Created Using Individualized and Non-Individualized HRTF ("Nishimura") | 2008 | Nishimura; ICAD |
| Localization Using Nonindividualized Head-Related Transfer Functions ("Wenzel 1993") | 1993 | Wenzel; Journal of Acoustical Society of America |
| Locating virtual sound sources at arbitrary distances in real-time binaural reproduction ("Villegas") | 2015 | Villegas; Virtual Reality |
| Location Models for Augmented Environments ("Gobmann") | 2002 | Gobmann; Personal and Ubiquitous Computing |
| Low-cost virtual reality environment for engineering and construction ("Hilfert") | 2016 | Hilfert; Visualization in Engineering |
| Making Immersive Virtual Reality Possible in Mobile ("Qualcomm") | 2016 | Qualcomm; Qualcomm |
| Manual for VisiSonics' RealSpace3D Audio Unity Plugin ("RealSpace 3D") | 2015 | VisiSonics Corporation |
| Modal Expansion of HRTFs: Continuous Representation In Frequency-Range-Angle ("Zhang 2009") | 2009 | Zhang; ICASSP 2009 |
| Motion Tracking: No Silver Bullet, but a Respectable Arsenal ("Welch 2002") | 2002 | Welch; IEEE Computer Society |
| Motion-Tracking in Spatial Mobile Audio-Conferencing ("Billinghurst 2007") | 2007 | Billinghurst; Association for Computing Machinery |
| MPEG Surround binaural rendering – Surround sound for mobile devices ("Plogsties") | 2006 | Plogsties; VDT International Convention |
| Multi-Channel Goes Mobile: MPEG Surround Binaural Rendering ("Breebaart") | 2006 | Breebaart; AES 29th International Conference, Seoul, Korea |
| Multidimensional Audio Window Management ("Cohen 1991 I") | 1991 | Cohen; International Journal of Man-Machine Studies |
| Audio Windows for Binaural Telecommunication ("Cohen 1991 III") | 1991 | Cohen; Institute of Electronics, Information and Communication Engineers |
| 3D User Interfaces: Theory and Practice ("LaViola") | 2017 | LaViola; Pearson |
| Navigation with Auditory Cues in a Virtual Environment ("Lokki") | 2005 | Lokki; IEEE Computer Society |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| Navigational Audio Games: An Effective Approach Toward Improving Spatial Contextual Learning for Blind People ("Balan 2015") | 2015 | Balan; Int J Disabil Hum Dev 2015 |
| Near-Field HRTFs ("Lentz 2007") | 2007 | Lentz; DAGA 2007 |
| Off the Bench and into the Game: PSVR ("Nirvanist") | 2016 | The Nirvanist; Virtual Reality Pop |
| Optimizing Spatial Audio Telephony and Teleconferencing ("Hyder 2011") | 2011 | Hyder; University of Tübingen |
| Parametric Binaural Audio Coding ("Ojala") | 2010 | Ojala; IEEE Computer Society |
| Percepton of proximal sound sources in virtual auditory space by distance-variable head-related transfer functions ("Otani") | 2012 | Otanai; Acoustical Society of Japan |
| Performative Technologies for Heritgage Site Regeneration ("Betsworth") | 2014 | Betsworth; Personal and Ubiquitous Computing |
| Place is a Palimpsest: Augmented Reality and Experience of Place ("Toews") | 2011 | Toews; University of California, Santa Cruz |
| Placing the Participants of a Spatial Audio Conference Call ("Hyder 2010") | 2010 | Hyder; IEEE Computer Society |
| Precise Near-to-Head Acoustics with Binaural Synthesis ("Lentz 2006") | 2006 | Lentz; Journal of Virtual Reality and Broadcasting |
| Presence in Virtual Environments as a Function of Visual and Auditory Cues ("Hendrix 1995") | 1995 | Hendrix; IEEE Computer Society |
| Psychophysical Calibration for Controlling the Range of a Virtual Sound Source: Multidimensional Complexity in Spatial Auditory Display ("Martens") | 2001 | Martens; ICAD |
| Put That There ("MIT 1979") | 1979 | Massachusetts Institute of Technology; Massachusetts Institute of Technology |
| Real-time Dynamic Image-Source Implementation for Auralisation ("Campos") | 2013 | Campos; International Conference on Digital Audio Effects |
| Redirected Free Exploration with Distractors: A Large-Scale, Real-Walking Locomotion Interface ("Peck 2010") | 2010 | Peck; University of North Carolina, Chapel Hill |
| Redirected Walking ("Razzaque") | 2001 | Razzaque; The Eurographics Association |
| Rendering Localized Spatial Audio in a Virtual Auditory Space ("Zotkin 2004") | 2004 | Zotkin; IEEE Transactions on Multimedia |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| Searching for Sources from a Fixed Point in a Virtual Auditory Environment ("Roginska 2011") | 2011 | Roginska; ICAD |
| Shared Space: Explorations in Collaborative Augmented Reality ("Billinghurst 2002") | 2002 | Billinghurst; University of Washington |
| Simplifying Orientation Measurement for Mobile Audio Augmented Reality Applications ("Heller") | 2014 | Heller; Association for Computing Machinery |
| Simulation, Visualization and Perception of Sound in Virtual Environment Using Beamforming ("Navvab") | 2012 | Navvab; BeBeC |
| SLAB - A Software-based Real-time Virtual Acoustic Environment Rendering System ("Miller 2001") | 2001 | Miller; ICAD |
| Sonification of 3D Scenes Using Personalized Spatial Audio to Aid Visually Impaired Persons ("Bujacz") | 2011 | Bujacz; ICAD |
| Sound Externalization: A Review of Recent Research ("Best") | 2020 | Best; Trends in Hearing |
| Soundscape Models and Compositional Strategies in Acousmatic Music ("Loufopoulos") | 1996 | Loufopoulous; Soundscape, The Journal of Acoustic Ecology |
| Source Directivity and Spatial Audio for Interactive Wavebased Sound Propagation ("Mehra") | 2014 | Mehra; ICAD |
| Spatial Audio Teleconferencing - Which Way is Better ("Evans") | 1997 | Evans; ICAD |
| Spatial Auditory Human-Computer Intefaces ("Sodnik") | 2015 | Sodnik; Springer |
| Spatial sound will be a critical component of Mixed Reality ("Curtin") | 2017 | Curtin; The Next Web |
| Spatialized Audio Multiparty Teleconferencing with Commodity Miniature Microphone Array ("Nguyen") | 2013 | Nguyen; Association for Computing Machinery |
| Spherical Microphone Array Based Immersive Audio Scene Rendering ("O'Donovan") | 2008 | O'Donovan; ICAD |
| Study and Comparison of Efficient Methods for 3D Audio Spatialization Based on Linear Decomposition of HRTF Data ("Larcher") | 2000 | Larcher; Audio Engineering Society |
| Supporting Free Walking in a Large Virtual Environment: Imperceptible Redirected Walking with an Immersive Distractor ("Chen 2017") | 2017 | Chen; Proceedings of the Computer Graphics International Conference |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| Tailored Audio Augmented Environments for Museums ("Terrenghi") | 2004 | Terrenghi; Intelligent User Interfaces |
| Texture-Less Object Tracking with Online Training Using An RGB-D Camera ("Park") | 2011 | Park; IEEE |
| The Accuracy of Localizing Virtual Sound Sources: Effects of Pointing Method and Visual Environment ("Majdak") | 2008 | Majdak; Audio Engineering Society |
| The AMBLR: A Mobile Spatial Audio Music Browser ("Stewart") | 2011 | Stewart; IEEE Computer Society |
| The Ars VR headset showdown-Oculus Rift vs. HTC Vive ("Orland") | 2016 | Orland; Ars Technica |
| The Convolvotron: Real-time demonstration of reverberant viraul acoustic environments ("Foster") | 1991 | Foster; Journal of the Acoustical Society of America |
| The Design of Multidimensional Sound Inrefaces ("Cohen 1995") | 1995 | Cohen; Virtual Environments and Advanced Interface Design |
| The Detectability of Headtracker Latency in Virtual Audio Displays ("Brungar") | 2005 | Brungar; ICAD |
| The Effects of Spatial Separation in Distance on the Informational and Energetic Masking of a Nearby Speech Signal ("Brungart 2002") | 2002 | Brungart; Acoustical Society of America |
| The IEM-cube ("Zmölnig") | 2003 | Zmolnig; ICAD |
| The Influence of Presentation Speed and Spatial Location on Reaction Time to Auditory Displays ("Roginska 2007") | 2007 | Roginska; ICAD |
| The Real-Life Dangers of Augmented Reality ("Sabelman") | 2015 | Sabelman; IEEE Spectrum |
| The Rise of Reactive and Interactive Video Game Audio ("Pendergrass") | 2015 | Pendergrass; California State University |
| Throwing, Pitching, and Catching Sound: Audio Windowing Models and Modes ("Cohen 1993 II") | 1993 | Cohen; International Journal of Man-Machine Studies |
| To the Castle! A comparison of two audio guides to enable public discovery of historical events ("Fitzgerald") | 2012 | Fitzgerald; Personal and Ubiquitous Computing |
| Touch-Space: Mixed Reality Game Space Based on Ubiquitous, Tangible, and Social Computing ("Cheok") | 2002 | Cheok; Personal and Ubiquitous Computing |
| Twenty years of Ircam Spat: Looking Back, Looking Forward ("Carpentier") | 2015 | Carpentier; ICMC |
| Two Turntables and a Mobile Phone ("Bryan") | 2011 | Bryan; Zenodo |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| Using 3D Audio Guidance to Locate Indoor Static Objects ("Sandberg 2006") | 2006 | Sandberg; Proceedings of the Human Factors and Ergonomics Society |
| Virtual Acoustics Displays ("Wenzel 1990") | 1990 | Wenzel; IEEE |
| Virtual Acoustics: Opportunities and Limits of Spatial Sound Reproduction ("Vorlander") | 2008 | Vorlander; Archives of Acoustics |
| Virtual Audio Localization with Simulated Early Reflections and Generalized Head-Related Transfer Functions ("Reed") | 2009 | Reed; Montana State University |
| Virtual Auditory Display on a Smartphone for High-Resolution Acoustic Space by Remote Rendering ("Iwaya") | 2015 | Iwaya; 2015 International Conference on Intelligent Information Hiding and Multimedia Signal Processing |
| Virtual Auditory Space for Visually Impaired ("Storek") | 2013 | Storek; ICAD |
| Virtual Gain for Audio Windows ("Cohen 1998") | 1998 | Cohen; Presence Teleoperators & Virtual Environments |
| Virtual Reality, Chapter 3: High Fidelity Immersive Virtual Reality ("Gilson") | 2012 | Gilson; IntechOpen |
| Virtual Sound Localization by Blind People ("Dunai") | 2015 | Dunai; Archives of Acoustics |
| Visual Design Methods for Virtual Reality ("Alger") | 2015 | Alger; Alger |
| Visualizing Voice Locations: Amplifying the Effects of Spatial Audio with Simple Displays ("Kilgore") | 2006 | Kilgore; University of Toronto |
| Walking in a Cube: Novel Metaphors for Safely Navigating Large Virtual Environments in Restricted Real Workspaces ("Cirio") | 2012 | Cirio; IEEE Transactions on Visualization and Computer Graphics |
| Y-windows: Proposal for a Standard AUI Environment ("Kaltenbrunner") | 2002 | Kaltenbrunner; ICAD |
| 3D Audio Augmented Reality: Implementation and Experiments ("Sundareswaran") | 2003 | Sundereswaran; IEEE |
| 3-D Audio: Above and Behind You or Moving Low Left to Right? ("Wright") | 1996 | Wright; EDN |
| 3D Binaural Sound Reproduction Using a Virtual Ambisonic Approach ("Noisternig 2003 II") | 2003 | Noisternig; Virtual Environments, Human-Computer Interfaces, and Measurement Systems |



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| Publication Title | Date of Publication | Author and Publisher |
|---|---|---|
| 3D Virtual Worlds and the Metaverse: Current status and Future Possibilities | 2013 | Dionisio; ACM Computing Surveys |
| 3deSoundBox – a Scalable, Platform-Independent 3D Sound System for Virtual and Augmented Reality Applications ("Stampfl 2003") | 2003 | Stampfl; EUROGRAPHICS |
| 9/11: Building a World of Survivor Memories ("Berman") | 2005 | Berman; Human-Computer Interaction International 2005 |
| A 16-speaker Audio Visual Display Interface and Control System ("O'Dwyer") | 2004 | O'Dwyer; ICAD |
| A 3D Audio Augmented Reality System for Cultural Heritage Management and Fruition ("D'Auria 2015") | 2015 | D'Auria; Journal of Digital Information Management |

| Product or Use | Person or Entity |
|---|---|
| Prior art systems developed and/or used by, or known to, experts engaged by Plaintiff or Defendants | The parties' experts |
| Prior art systems developed and/or used by, or known to, the named inventors on the Asserted Patents or prior artists named on references cited in these invalidity contentions | Named inventors on the Asserted Patents and pertinent prior artists. |
| Prior art systems revealed by further discovery, including prior art Meta and/or Oculus systems and third-party systems (e.g., Meta and/or Oculus systems that constitute prior art to the Asserted Claims because those claims are not entitled to the priority dates Plaintiff asserts) | Meta and others |

## IV. THE ASSERTED CLAIMS ARE ANTICIPATED AND/OR OBVIOUS

Prior art references and systems that anticipate and/or render obvious the Asserted Claims of the Asserted Patents are identified above and in Defendants' claim charts, which demonstrate how the prior art anticipates and/or renders obvious each and every element of the Asserted Claims, and discloses and/or renders obvious those claims as a whole. To the extent an element or claim is not disclosed and/or rendered obvious by each primary reference charted, on its own, the claim is rendered obvious by combinations with one or more other prior art references identified, including as mapped in Defendants' charts.



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Furthermore, to the extent a finder of fact determines that a limitation of any of the Asserted Claims is not disclosed by one of the references and/or systems identified above, discussed further below, and/or charted in these invalidity contentions, or combinations identified, discussed, and/or mapped and charted in these contentions, the claims nevertheless are unpatentable as obvious because they contain nothing that constitutes patentable innovation. No Asserted Claim goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

### A. The '196 Patent

As further explained below and in Exhibits A-01 to A-17, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the '196 Patent under 35 U.S.C. § 102 and/or § 103:

- Bailey, alone or in view of one or more of the prior art references and products identified in Section IV.J.1-4, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Bailey and Bedingfield and Hammershoi, (ii) Bailey and Bedingfield and Nystrom, (iii) Bailey and Boustead and Nystrom, (iv) Bailey and Boustead and Pedersen, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Ballas 439, alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 2, 3, 4, 8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Ballas 439 and Li 305, (ii) Ballas 439 and Bedingfield, (iii) Ballas 439 and Pedersen and Gardner, (iv) Ballas 439 and Jarvinen and Gardner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Bedingfield, alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 2, 3, 4, 8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Bedingfield in view of Ballas 123, (ii) Bedingfield in view of Sandgren, (iii) Bedingfield and Bailey and Hammershoi, (iv) Bedingfield and Bailey and Nystrom, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Begault 2000 alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Begault 2000 and Bedingfield, (ii) Begault 2000 and Pedersen,



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(iii) Begault 2000 and Jarvinen and Gardner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Boustead alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, and 4, and/or Section IV.A, for example and without limitation (i) Boustead and Gardner and Nystrom, (ii) Boustead and Gardner and Pedersen, (iii) Boustead and Bailey and Nystrom, (iv) Boustead and Bailey and Pedersen, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- CU-SeeMe VR System alone or in view of one or more of the prior art references and products identified in Section IV.J.1-4, 8, and/or 12, and/or Section IV.A, for example and without limitation (i) CU-SeeMe VR System and Bailey and Nystrom, (ii) CU-SeeMe VR System and Bailey and Pedersen, (iii) CU-SeeMe VR and Gardner and Nystrom, (iv)Gardner and Pedersen, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Etter 419 alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, and 8, and/or Section IV.A, for example and without limitation (i) Etter 419 and Bailey and Jarvinen, (ii) Etter 419 and Bailey and Bedingfield, (iii) Etter 419 and Gardner and Jarvinen, (iv) Etter 419 and Gardner and Bedingfield, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Gardner alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, and/or 4, and/or Section IV.A, for example and without limitation (i) Gardner and Bedingfield and Hammershoi, (ii) Gardner and Bedingfield and Nystrom, (iii) Gardner and Boustead and Nystrom, (iv) Gardner and Boustead and Pedersen, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Hammershoi alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Hammershoi and Bedingfield and Gardner, (ii) Hammershoi and Bedingfield and Bailey, (iii) Hammershoi and Jarvinen and Gardner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Jarvinen alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 4, 8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Jarvinen and Hammershoi and Gardner, (ii) Jarvinen and Nystrom and Gardner, (iii) Jarvinen and Li 305 and Gardner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Knappe alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-4, and/or 8, and/or Section IV.A, for example and without limitation (i) Knappe and Pedersen and Bailey, (ii) Knappe and Pedersen and Gardner, (iii) Knappe and Bedingfield and Bailey, (iv) Knappe and Bedingfield and Gardner,



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which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Li 305 alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 2, 4, 8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Li 305 in view of Ballas 123, (ii) Li 305 in view of Sandgren, (iii) Li 305 and Jarvinen and Gardner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Nystrom alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 4, 8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Nystrom and Gardner and Jarvinen, (ii) Nystrom and Bedingfield and Gardner, (iii) Nystrom and Bedingfield and Bailey, (iv) Nystrom and Boustead and Gardner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedersen, alone or in view of one or more of the prior art references and products identified in Section IV.J.8, 10, and/or 12, and/or Section IV.A, for example and without limitation (i) Pedersen and Begault 2000, (ii) Pedersen and Gardner, (iii) Pedersen and Bailey, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Billinghurst System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 8, and/or 12, and/or Section IV.A, for example and without limitation (i) Billinghurst System and Nystrom and Gardner, (ii) Billinghurst System and Nystrom and Bailey, (iii) Billinghurst System and Begault 2000 which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Gamper AAR System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 8, and/or 12, and/or Section IV.A, for example and without limitation (i) Gamper AAR System and Bailey and Nystrom, (ii) Gamper AAR System and Bailey and Pedersen, (iii) Gamper AAR System and Gardner and Nystrom, (iv) Gamper AAR System and Gardner and Pedersen, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

#### 1. U.S. Patent No. 6,961,439 ("Ballas 439")

The chart attached as Exhibit A-01 provides examples of where Ballas 439 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ballas 439 does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Ballas 439 with concepts and features disclosed



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in other prior art references and products identified in Sections IV.J.1, 2, 3, 4, 8, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Ballas 439 and/or Ballas 439 and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. For example, providing the remote and/or local user(s) with a wearable electronic device equipped with one or more microphones capable of recording binaural audio in combination with the auditory system disclosed in Ballas 439 is one commonsense and predictable means to provide spatial audio during a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Additionally, spatial audio can be useful whenever a listener is presented with multiple auditory streams, or where the user would



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benefit from increased immersion in an environment, such as in a teleconferencing environment. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase user immersion in a virtual teleconference. Furthermore, providing the user with spatial audio during a telephone call is achievable by, for example, adapting well-known techniques for creating and adjusting binaural audio based on reverberation. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. A POSA likewise would have known and been motivated to provide users with wearable electronic devices that includes microphone(s) to record binaural audio. Furthermore, a POSA would have known and been motivated to enable commands for moving sound sources. A POSA also would have known and been motivated to adapt binaural audio based on reverberation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ballas 439 does not disclose and/or render obvious one or more limitations of the Asserted Claims of the ’196 Patent.



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### 2. U.S. Patent No. 9,632,683 ("Jarvinen")

The chart attached hereto as Exhibit A-02 provides examples of where Jarvinen discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Jarvinen does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Jarvinen with concepts from other prior art references and products identified in Sections IV.J.1, 4, 8, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Jarvinen and/or Jarvinen and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the apparatus disclosed in Jarvinen. Additionally, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users' heads or users' positions and adjusting binaural audio from sound sources accordingly. The prior art teaches



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techniques for this, such as attaching conventional sensors (e.g. horizon sensor, gravity sensor, accelerometer, gyroscope, or magnetometer) to a wearable electronic device. The prior art further teaches that well-known techniques for creating and adjusting binaural audio based on reverberation can be used to provide the user with spatial audio during a telephone call. Additionally, head tracking and spatialized audio allows for rich manipulation of an audio scene because each audio object may be individually manipulated. In particular, by using these well-known techniques taught in the prior art a user may increase the loudness of certain audio objects over others in a natural and intuitive way. A POSA would have known and been motivated to use the well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, to increase user interactivity within an audio scene. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that include microphone(s) to record binaural audio. And, a POSA would have known and been motivated to enable commands to move sound sources. A POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Jarvinen does not disclose and/or render obvious one or more limitations of the Asserted Claims of the '196 Patent.

### 3. U.S. Patent No. 9,307,331 ("Pedersen")

The chart attached hereto as Exhibit A-03 provides examples of where Pedersen discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Pedersen does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Pedersen with concepts from other prior art references and products identified in Sections IV.J.8, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Pedersen and/or Pedersen and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been



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motivated to combine these commonplace wearable electronic devices with the apparatus disclosed in Pedersen. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Additionally, the prior art teaches that spatialized audio increases the user's speech reception threshold (SRT), including for speech in an environment with multiple speakers (such as teleconferencing). Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase user comprehension and comfort in a virtual teleconference. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. A POSA likewise would have known and been motivated to provide users with wearable electronic devices to play and record binaural voice audio. Furthermore, a POSA would have known and been motivated to enable commands to move sound sources. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedersen does



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not disclose one or more limitations of the Asserted Claims of the ’196 Patent.

#### 4. U.S. Patent Pub. No. 2010/0328419 (“Etter 419”)

The chart attached hereto as Exhibit A-04 provides examples of where Etter 419 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Etter 419 does not anticipate and/or render obvious the Asserted Claims of the ’196 Patent on its own, it would have been obvious to combine or modify Etter 419 with concepts from other prior art references and products identified in Sections IV.J.1, 3, and/or 8 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’196 Patent are not disclosed and/or rendered obvious by Etter 419 and/or Etter 419 and such references, the Asserted Claims of the ’196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood video and spatial audio teleconferencing systems were ubiquitous in both business and personal applications. And commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. For example, providing the remote and/or local user(s) with a wearable electronic device equipped with one or more microphones capable of recording binaural audio in combination with the auditory system disclosed in Etter 419 is one commonsense and predictable



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means to provide spatial audio during a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Furthermore, using well-known techniques for creating and adjusting binaural audio based on reverberation would be a commonplace and predictable way to create a more immersive and enjoyable VR experience. Additionally, the prior art teaches that spatialized audio improves the user's accuracy of matching an auditory space to a corresponding visual space. Accordingly, a POSA would have known and been motivated to employ spatial audio to increase user immersion and utility. A POSA would have known and been motivated to use well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J to increase the realism of a virtual teleconference. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that include microphone(s) to record binaural audio. And, a POSA would have known and been motivated to enable commands to move sound sources. A POSA



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would have known and been motivated to adapt binaural audio based on reverberation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Etter 419 does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**5. U.S. Patent No. 8,406,439 ("Bedingfield")**

The chart attached hereto as Exhibit A-05 provides examples of where Bedingfield discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Bedingfield does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Bedingfield with concepts from other prior art references and products identified in Sections IV.J.1, 2, 3, 4, 8, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Bedingfield and/or Bedingfield and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are



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used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the apparatus disclosed in Bedingfield. The prior art further teaches that well-known techniques for creating and adjusting binaural audio based on reverberation can be used to provide the user with spatial audio during a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Additionally, spatialized audio and manipulation of audio objects improves user comprehension and spatial reference within a virtual environment. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase focus on specific participants. Furthermore, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that include microphone(s) to record binaural audio. And, a POSA would have known and been motivated to enable commands to move sound sources. A POSA would also have known and been motivated to adapt binaural audio based on



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reverberation. Design incentives and market forces would have prompted those endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Bedingfield does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**6. U.S. Patent Pub. No. 2009/0052703 ("Hammershoi")**

The chart attached hereto as Exhibit A-06 provides examples of where Hammershoi discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Hammershoi does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Hammershoi with concepts from other prior art references and products identified in Sections IV.J.1, 3, 8, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Hammershoi and/or Hammershoi and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual



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experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Furthermore, providing the user with spatial audio during a telephone call is achievable by, for example, adapting well-known techniques for creating and adjusting binaural audio based on reverberation. Additionally, as taught in the prior art, it was well-known that spatialized audio and the ability to manipulate objects improves binaural synthesis within virtual reality and teleconferences. Additionally, it was well-known and well-understood that a higher degree of individual adaptation of HRTFs improves audio synthesis and increases user immersion. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the accuracy of spatial audio for 3D head tracking devices. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to enable commands to move sound sources. And, a POSA would have known and been motivated to adapt binaural audio based on reverberation. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Hammershoi does not disclose one or more limitations of the Asserted Claims of the ’196 Patent.

**7. 3-D Sound for Virtual Reality and Multimedia (“Begault 2000”)**

The chart attached hereto as Exhibit A-07 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault 2000 does not anticipate and/or render obvious the Asserted Claims of the ’196 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts from other prior art references and products identified in Sections IV.J.1, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’196 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the ’196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the apparatus



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disclosed in Begault 2000. Additionally, as taught in the prior art, it was well-known that spatialized audio and the ability to manipulate objects improves binaural synthesis within virtual reality and teleconferences. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase user immersion in virtual environments with 3-D auditory sound. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**8. U.S. Patent No. 8,559,646 ("Gardner")**

The chart attached hereto as Exhibit A-08 provides examples of where Gardner discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Gardner does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Gardner with concepts from other prior art references and products identified in Sections IV.J.1, 3, and/or 4 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Gardner and/or Gardner



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and such references, the Asserted Claims of the ’196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the apparatus disclosed in Gardner. The prior art further teaches that well-known techniques for creating and adjusting binaural audio based on reverberation can be used to provide the user with spatial audio during a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Additionally, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users’ heads or users’ positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching a sensor to a wearable electronic device, or receiving signals from devices located at the user’s ears. Additionally, it was well-known that providing spatialized audio improves user



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comprehension, intelligibility and speaker identification. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the realism of the auditory scene in the virtual world. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that includes microphone(s) to record binaural audio. And a POSA would have known and been motivated to enable commands to move sound sources. A POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Gardner does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**9. U.S. Patent No. 9,961,208 ("Boustead")**

The chart attached hereto as Exhibit A-09 provides examples of where Boustead discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Boustead does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it



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would have been obvious to combine or modify Boustead with concepts from other prior art references and products identified in Sections IV.J.1, 3, and/or 4 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Boustead and/or Boustead and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with audio conferencing system disclosed in Boustead. Furthermore, providing the user with spatial audio during a telephone call is achievable by, for example, adapting well-known techniques for creating and adjusting binaural audio based on reverberation. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Furthermore, the provision of spatial audio during telephone calls utilizes



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well-known techniques, including, for example, tracking the orientation of users' heads or users' positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching a sensor to a wearable electronic device, or receiving signals from devices located at the user's ears. Additionally, providing spatialized audio improves the user's ability to differentiate between speakers during a conference call by emphasizing dominant speakers. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, enable the user to focus on specific speakers or their locations during a conference call. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that include microphone(s) to record binaural audio. And, a POSA would have known and been motivated to enable commands to move sound sources. A POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Boustead does



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not disclose one or more limitations of the Asserted Claims of the ’196 Patent.

**10. U.S. Patent No. 6,850,496 (“Knappe”)**

The chart attached hereto as Exhibit A-10 provides examples of where Knappe discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Knappe does not anticipate and/or render obvious the Asserted Claims of the ’196 Patent on its own, it would have been obvious to combine or modify Knappe with concepts from other prior art references and products identified in Sections IV.J.1, 2, 3, 4, and/or 8 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’196 Patent are not disclosed and/or rendered obvious by Knappe and/or Knappe and such references, the Asserted Claims of the ’196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices which can be equipped with one or more sensors capable of tracking head orientation and/or user position are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the virtual conferencing system disclosed in Knappe. Furthermore, the provision of spatial audio during



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telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users' heads or users' positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching a sensor to a wearable electronic device, or receiving signals from devices located at the user's ears. And, providing the user with spatial audio during a telephone call is achievable by, for example, adapting well-known techniques for creating and adjusting binaural audio based on reverberation. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. The prior art further teaches that when two people's voices can be perceived as arriving from distinctly different directions, binaural hearing allows a listener to more easily recognize who is talking, and in many instances, focus on what one person is saying even though two or more people are talking simultaneously. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, enable the user to access broadcast streams for individual participants. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural



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audio. And, a POSA would have known and been motivated to enable commands to move sound sources. Furthermore, a POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Knappe does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**11. U.S. Patent No. 9,131,305 ("Li 305")**

The chart attached hereto as Exhibit A-11 provides examples of where Li 305 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Li 305 does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Li 305 with concepts from other prior art references and products identified in Sections IV.J.1, 2, 4, 8, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Li 305 and/or Li 305 and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a



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telephone call. Additionally, commonplace and well-understood wearable electronic devices which can be equipped with one or more sensors capable of tracking head orientation and/or user position are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the virtual conferencing system disclosed in Li 305. The prior art teaches techniques for this, such as attaching a sensor to a wearable electronic device, or receiving signals from devices located at the user's ears. And, providing the user with spatial audio during a telephone call is achievable by, for example, adapting well-known techniques for creating and adjusting binaural audio based on reverberation. Additionally, it was well-known that providing spatialized audio improves the realism of binaural recordings, thereby increasing user immersion and comprehension. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, enable a sound system to perform 3D sound recording with enhanced audio to improve the user's experience. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation to adjust spatial audio. Furthermore, a POSA would have known and been motivated to provide each conference participant with a wearable device capable of tracking the user's head orientation. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Li 305 does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**12. U.S. Patent No. 9,118,991 ("Nystrom")**

The chart attached hereto as Exhibit A-12 provides examples of where Nystrom discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Nystrom does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Nystrom with concepts from other prior art references and products identified in Sections IV.J.1, 3, 4, 8, 10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Nystrom and/or Nystrom and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques for creating and adjusting binaural audio based on reverberation, to improve spatial audio during a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the



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audio system disclosed in Nystrom. Furthermore, it was known and well-understood that wearable electronic devices equipped with one or more sensors capable of tracking head orientation and/or user position enabled systems to more accurately adjust binaural audio. Moreover, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Likewise, it was known and well-understood that providing spatialized audio and head orientation tracking improves the emulation of sound sources in a 3D audio system, thereby increasing user enjoyment, immersion and comprehension. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the realism of the user's audio experience during, for example, a telephone call. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that include sensors and microphone(s) to record binaural audio. Additionally, a POSA would have known and been motivated to enable commands to move sound sources. A POSA would have known and been motivated to adapt binaural audio based on



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reverberation and to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Nystrom does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**13. U.S. Patent No. 7,606,375 ("Bailey")**

The chart attached hereto as Exhibit A-13 provides examples of where Bailey discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Bailey does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Bailey with concepts from other prior art references and products identified in Sections IV.J.1-4, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Bailey and/or Bailey and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques for creating and adjusting binaural audio based on reverberation, to improve spatial audio during a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have



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known and been motivated to combine these commonplace wearable electronic devices with the audio system disclosed in Bailey. Furthermore, it was known and well-understood that wearable electronic devices equipped with one or more sensors capable of tracking head orientation and/or user position enabled systems to more accurately adjust binaural audio. Moreover, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Likewise, it was known and well-understood that providing spatialized audio and head orientation tracking improves the emulation of sound sources in a 3D audio system, thereby increasing user enjoyment, immersion and comprehension. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the realism of the user's audio experience during, for example, a telephone call. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve realistic reverberation of sound for users based on the well-known techniques of capturing and processing binaural audio during a telephone call. Furthermore, a POSA would have known and been motivated to provide users with wearable electronic devices that include sensors and microphone(s) to record binaural audio. Additionally, a POSA would have known and been



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motivated to enable commands to move sound sources. A POSA would have known and been motivated to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Bailey does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

**14. CU-SeeMe VR ("CU-SeeMe VR System")**

The chart attached hereto as Exhibit A-15 provides examples of where CU-SeeMe VR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent CU-SeeMe VR System does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify CU-SeeMe VR System with concepts from other prior art references and products identified in Sections IV.J.1-4, 8, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by CU-SeeMe VR System and/or CU-SeeMe VR a System and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a



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telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the CU-SeeMe VR System video-conferencing system. Additionally, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users' heads or users' positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching conventional sensors (e.g. horizon sensor, gravity sensor, accelerometer, gyroscope, or magnetometer) to a wearable electronic device. The prior art further teaches that well-known techniques for creating and adjusting binaural audio based on reverberation can be used to provide the user with spatial audio during a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. A POSA would have known and been motivated to combine Additionally, spatialized audio and manipulation of objects enables the user to immerse themselves in the immersive 3D chat environment of the CU-SeeMe VR System. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the user's ability to intuitively interact with the virtual conference room. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and



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well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, POSA would have known and been motivated to provide users with wearable electronic devices that includes microphone(s) to record binaural audio. Additionally, a POSA would have known and been motivated to enable commands to move sound sources relative to the user using graphical user interface. A POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the CU-SeeMe VR System does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

### 15. Wearable Spatial Conferencing Space system with Virtual i-O iglasses ("Billinghurst System")

The chart attached hereto as Exhibit A-14 provides examples of where Billinghurst System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Billinghurst System does not anticipate and/or render obvious the Asserted Claims of the '196 Patent on its own, it would have been obvious to combine or modify Billinghurst System with concepts from other prior art references and products identified in Sections IV.J.1, 3, 8, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '196 Patent are not disclosed and/or rendered obvious by Billinghurst System and/or Billinghurst System and such references, the Asserted Claims of the '196 Patent are nevertheless unpatentable as obvious because they contain



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nothing that constitutes patentable innovation—no Asserted Claim of the ’196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. A POSA would have known and been motivated to combine these commonplace wearable electronic devices with the Billinghurst System such that more than one participants wears an electronic device. Additionally, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users’ heads or users’ positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching conventional sensors (e.g. horizon sensor, gravity sensor, accelerometer, gyroscope, or magnetometer) to a wearable electronic device. The prior art further teaches that well-known techniques for creating and adjusting binaural audio based on reverberation can be used to provide the user with spatial audio during a telephone call. providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Additionally, it was well known that spatialized audio and manipulation of objects



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enables the user to more easily discriminate between audio sources. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the user's ability to interact with specific individuals during a virtual conference call. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to provide multiple users with wearable electronic devices that includes microphone(s) to record binaural audio. Likewise, a POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation using sensors to adjust spatial audio. Furthermore, a POSA would have known and been motivated to enable commands to move sound sources relative to the user. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Billinghurst System does not disclose one or more limitations of the Asserted Claims of the '196 Patent.

### 16. AAR system with MARA Headset ("Gamper AAR System")

The chart attached hereto as Exhibit A-16 provides examples of where Gamper AAR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '196 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Gamper AAR System does not anticipate and/or render obvious the Asserted Claims of the



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’196 Patent on its own, it would have been obvious to combine or modify Gamper AAR System with concepts from other prior art references and products identified in Sections IV.J.1, 3, 8, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’196 Patent are not disclosed and/or rendered obvious by Gamper AAR System and/or Gamper AAR System and such references, the Asserted Claims of the ’196 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’196 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users’ heads or users’ positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching conventional sensors (e.g. horizon sensor, gravity sensor, accelerometer, gyroscope, or magnetometer) to a wearable electronic device. The prior art further teaches that well-known techniques for creating and adjusting binaural audio based on reverberation can be used to provide the user with spatial audio during a telephone call. Additionally, providing the user with a more immersive and enjoyable virtual experience is also achievable by, for example, enabling users to command the system to move sound sources between various points in space. The prior art teaches techniques for this, such as detecting user hand gestures, providing a graphic user interface to manipulate participant sound source locations, and allowing users to move an avatar within a virtual environment. Additionally, spatialized audio



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and manipulation of objects enables the user to segregate multiple speakers during a virtual conversation. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the user's presence and immersion in the virtual world. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of capturing and processing binaural audio. Furthermore, a POSA would have known and been motivated to adapt binaural audio based on reverberation and to track users' head orientation using sensors to adjust spatial audio. Additionally, a POSA would have known and been motivated to enable commands to move sound sources relative to the user. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Gamper AAR System does not disclose one or more limitations of the Asserted Claims of the '196 Patent

**B. The '628 Patent**

As further explained below and in Exhibits B-01 to B-17, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the '628 Patent under 35 U.S.C. § 102 and/or § 103:



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- Ballas 439, alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 2, 3, 4, 6, 8, and/or 10-12, and/or Section IV.B, for example and without limitation (i) Ballas 439 in view of Otto 440, (ii) Ballas 439 in view of Otto in further view of Haddick 248, (iii) Ballas 439 and Bedingfield and Pedersen, (iv) Ballas 439 and Begault 2000 and Craner, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedersen, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 8, 10, and/or 12, and/or Section IV.B, for example and without limitation (i) Pedersen and Hammershoi and Ballas 439, (ii) Pedersen and Hammershoi and Haddick 248, (iii) Pedersen and Ballas 439 and Bedingfield, (iv) Pedersen and Haddick 248 and Bedingfield, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Etter 419 alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, and/or 6, and/or Section IV.B, for example and without limitation (i) Etter 419 and Ballas 439 and Craner and Schroder, (ii) Etter 419 and Ballas 439 and Nystrom and Schroder, (iii) Etter 419 and Haddick 248 and Craner and Schroder, (iv) Etter 419 and Haddick 248 and Nystrom and Schroder, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Bedingfield, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 6, 9-10, and/or 12, and/or Section IV.B, for example and without limitation (i) Bedingfield and Ballas 439 and Pedersen, (ii) Bedingfield and Haddick 248 and Pedersen, (iii) Bedingfield and Billinghurst System and Schroder, (iv) Bedingfield and Billinghurst System and Otto 440, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Hammershoi alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 9-10, and/or 12, and/or Section IV.B, for example and without limitation (i) Hammershoi and Ballas 439 and Pedersen, (ii) Hammershoi and Haddick 248 and Pedersen, (iii) Hammershoi and Ballas 439 and Boustead, (iv) Hammershoi and Haddick 248 and Boustead, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Begault 2000, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, and/or 6, and/or Section IV.B, for example and without limitation (i) Begault 2000 and Ballas 439 and Craner, (ii) Begault 2000 and Haddick 248 and Craner, (iii) Begault 2000 and Ballas 439 and Nystrom and/or Otto 440, (iv) Begault 2000 and Ballas 439 and Nystrom and/or Otto 440, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.



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- Gardner alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 4, and/or 6, and/or Section IV.B, for example and without limitation (i) Gardner and Ballas 439 and Schroder, (ii) Gardner and Ballas 439 and Otto 440, (iii) Gardner and Haddick 248 and Schroder, (iv) Gardner and Haddick 248 and Otto 440, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Nystrom alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 4, 9-10, and/or 12, and/or Section IV.B, for example and without limitation (i) Nystrom and Ballas 439, (ii) Nystrom and Haddick 248 and Hammershoi, (iii) Nystrom and Billinghurst System, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Craner alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 4, 6, and/or 9, and/or Section IV.B, for example and without limitation (i) Craner and Ballas 439 and Begault 2000, (ii) Craner and Haddick 248 and Begault 2000, (iii) Craner and Ballas 439 and Etter 419 and Schroder, (iv) Craner and Haddick 248 and Etter 419 and Schroder, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Haddick 248, alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 6, and/or 8, and/or Section IV.B, for example and without limitation (i) Haddick 248 and Bedingfield and Pedersen, (ii) Haddick 248 and Begault 2000 and Craner, (iii) Haddick 248 and Billinghurst System and Schroder, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Otto 440 alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, and/or 6, and/or Section IV.B, for example and without limitation (i) Otto 440 and Ballas 439 and Gardner, (ii) Otto 440 and Haddick 248 and Gardner, (iii) Otto 440 and Billinghurst System, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Schroder alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 9-10, and/or 12, and/or Section IV.B, for example and without limitation (i) Schroder and Billinghurst System, and/or Haddick 248, (ii) Schroder and Ballas 439 and Craner and Etter 419, (iii) Schroder and Ballas 439 and Nystrom and Etter 419, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- CU-SeeMe VR System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 4, 6, and/or 12, and/or Section IV.B, for example and without limitation (i) CU-SeeMe VR System and Ballas 439 and Otto 440, (ii) CU-SeeMe VR System and Ballas 439 and Schroder, (iii) CU-SeeMe VR System and Haddick 248 and Otto 440, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.



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- Billinghurst System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 6, 8, 9, and/or 12, and/or Section IV.B, for example and without limitation (i) Billinghurst System in view of Schroder, (ii) Billinghurst System in view of Schroder in further view of Zhou and/or Haddick 248, (iii) Billinghurst System and Craner, (iv) Billinghurst System and Gamper AAR System and Otto 440, (v) Billinghurst System and Gamper AAR System and Schroder, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Gamper AAR System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 6, 9-10, and/or 12, and/or Section IV.B, for example and without limitation (i) Gamper AAR System and Billinghurst System and Otto 440, (ii) Gamper AAR System and Billinghurst System and Schroder, (iii) Gamper AAR System and Second Life, and Ballas 439 and/or Haddick 248, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

#### 1. U.S. Patent No. 6,961,439 ("Ballas 439")

The chart attached as Exhibit B-01 provides examples of where Ballas 439 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ballas 439 does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Ballas 439 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 3, 4, 6, 8, and/or 10-12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Ballas 439 and/or Ballas 439 and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for



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example, the reasons discussed above in Section IV.A.1. In addition, the prior art discloses well-known techniques for displaying virtual images to the user that represent one or more participants during a telephone conference or other communication. To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to add visual representations of conference call participants to improve realism and immersiveness during a virtual experience. Furthermore, a POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ballas 439 does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

**2. U.S. Patent No. 9,307,331 ("Pedersen")**

The chart attached as Exhibit B-03 provides examples of where Pedersen discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Pedersen does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Pedersen with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 8, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious



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by Pedersen and/or Pedersen and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.3. In addition, the prior art discloses well-known techniques for displaying virtual images to the user that represent one or more participants during a telephone conference or other communication. Additionally, it was well understood that processing audio, such as participants' voices during a telephone conference, with various head related transfer functions improves audio synthesis and increases user immersion.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to add visual representations of conference call participants to improve realism and immersiveness during a virtual experience. Furthermore, a POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedersen does not disclose one or more limitations of the Asserted Claims of the '628 Patent.



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### 3. U.S. Patent Pub. No. 2010/0328419 ("Etter 419")

The chart attached as Exhibit B-04 provides examples of where Etter 419 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Etter 419 does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Etter 419 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Etter 419 and/or Etter 419 and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.4. In addition, the prior art discloses well-known techniques for displaying virtual images to the user that represent one or more participants during a telephone conference or other communication. Additionally, it was well understood that processing audio, such as participants' voices during a telephone conference, with various head related transfer functions improves audio synthesis and increases user immersion.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to add visual



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representations of conference call participants to improve realism and immersiveness during a virtual experience. Furthermore, a POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Etter 419 does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

#### 4. U.S. Patent No. 8,406,439 ("Bedingfield")

The chart attached as Exhibit B-05 provides examples of where Bedingfield discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Bedingfield does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Bedingfield with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 6, 9-10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Bedingfield and/or Bedingfield and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.5. In addition, the prior art discloses well-



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known techniques for displaying virtual images to the user that represent one or more participants during a telephone conference or other communication. Additionally, it was well understood that processing audio, such as participants' voices during a telephone conference, with various head related transfer functions improves audio synthesis and increases user immersion.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to add visual representations of conference call participants to improve realism and immersiveness during a virtual experience. Furthermore, a POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Bedingfield does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

**5. U.S. Patent Pub. No. 2009/0052703 ("Hammershoi")**

The chart attached as Exhibit B-06 provides examples of where Hammershoi discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Hammershoi does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Hammershoi with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 9-10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to



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determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by Hammershoi and/or Hammershoi and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.6. In addition, the prior art discloses well-known techniques for displaying virtual images to the user that represent one or more participants during a telephone conference or other communication.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to add visual representations of conference call participants to improve realism and immersiveness during a virtual experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Hammershoi does not disclose one or more limitations of the Asserted Claims of the ’628 Patent.

#### 6. 3-D Sound for Virtual Reality and Multimedia (“Begault 2000”)

The chart attached as Exhibit B-07 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault



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2000 does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.7. To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the ’628 Patent.

**7. U.S. Patent No. 8,559,646 (“Gardner”)**

The chart attached as Exhibit B-08 provides examples of where Gardner discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Gardner does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify Gardner with concepts and features disclosed in



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other prior art references and products identified in Sections IV.J.1, 2, 4, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Gardner and/or Gardner and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA..

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.8. In addition, it was well understood that processing audio, such as participants' voices during a telephone conference, with various head related transfer functions improves audio synthesis and increases user immersion.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Gardner does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

**8. U.S. Patent No. 9,118,991 ("Nystrom")**

The chart attached as Exhibit B-09 provides examples of where Nystrom discloses, either



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expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Nystrom does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify Nystrom with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 4, 9-10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by Nystrom and/or Nystrom and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.12. To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Nystrom does not disclose one or more limitations of the Asserted Claims of the ’628 Patent.

**9. U.S. Patent No. 6,882,971 (“Craner”)**

The chart attached as Exhibit B-10 provides examples of where Craner discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Craner



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does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify Craner with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 4, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by Craner and/or Craner and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication or teleconferencing using spatialized audio. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users’ heads or users’ positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching a sensor to a wearable electronic device, or receiving signals from devices located at the user’s ears. Additionally, providing spatialized audio improves the user’s ability to differentiate between speakers during a teleconference. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase the user’s enjoyment when using a teleconferencing system. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive



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guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on well-known techniques of processing binaural audio. Additionally, a POSA would have known and been motivated to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Craner does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

**10. PCT Pub. No. WO 2013/049248 ("Haddick 248")**

The chart attached as Exhibit B-11 provides examples of where Haddick 248 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Haddick 248 does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Haddick 248 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 6, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Haddick 248 and/or Haddick 248 and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar



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elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, spatialized audio improves the ability for users to experience the surrounding environment when using the systems such as those described in Haddick 248. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase sensory capabilities of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on well-known techniques of processing binaural audio, such as through the use of HRTFs. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Haddick 248 does not disclose one or more limitations of the Asserted Claims of the ’628 Patent.

### 11. U.S. Patent No. 9,578,440 (“Otto 440”)

The chart attached as Exhibit B-13 provides examples of where Otto 440 discloses, either



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expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Otto 440 does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify Otto 440 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by Otto 440 and/or Otto 440 and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, it was well-known that spatialized audio improves the ability for users to experience the surrounding environment when using the systems such as those described in Otto 440. Furthermore, it was well understood that spatial audio contributes to realistic perception of a three dimensional virtual environment. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase sensory capabilities and improves the experience of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in



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textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on well-known techniques of processing binaural audio, such as through the use of HRTFs. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Otto 440 does not disclose one or more limitations of the Asserted Claims of the ’628 Patent.

**12. PCT Pub. No. WO 2005/032209 (“Schroder”)**

The chart attached as Exhibit B-02 provides examples of where Schroder discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Schroder does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify Schroder with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 9-10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by Schroder and/or Schroder and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements



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according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, the prior art teaches that spatialized audio improves the ability for users to experience the surrounding environment when using the systems such as those described in Schroder. Additionally, it was well understood that spatial audio contributes to realistic perception of a three dimensional virtual environment. It was also well-known that it desirable to change the HRTF filters as the user moved in order to maintain a realistic auditory environment. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase sensory capabilities of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on well-known techniques of processing binaural audio, such as HRTFs. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Schroder does not disclose one or more limitations of the Asserted Claims of the ’628 Patent.

### 13. CU-SeeMe VR (“CU-SeeMe VR System”)

The chart attached as Exhibit B-14 provides examples of where CU-SeeMe VR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent CU-SeeMe VR System does not anticipate and/or render obvious the Asserted Claims of the ’628 Patent on its own, it would have been obvious to combine or modify CU-SeeMe VR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 4, 6, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’628 Patent are not disclosed and/or rendered obvious by CU-SeeMe VR System and/or CU-SeeMe VR System and such references, the Asserted Claims of the ’628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

he reasons or motivation to combine this prior art would include, for example, the reasons discussed above in Section IV.A.14. In addition, it was well understood that processing audio, such as participants’ voices during a telephone conference, with various head related transfer functions improves audio synthesis and increases user immersion.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than



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predictable results. A POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the CU-SeeMe VR System does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

### 14. Wearable Spatial Conferencing Space system with Virtual i-O Glasses ("Billinghurst System")

The chart attached hereto as Exhibit B-12 provides examples of where Billinghurst System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Billinghurst System does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Billinghurst System with concepts from other prior art references and products identified in Sections IV.J.1, 6, 8, 9, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Billinghurst System and/or Billinghurst System and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.15. For example, it was well understood



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that processing audio, such as participants' voices during a telephone conference, with various head related transfer functions improves audio synthesis and increases user immersion.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to process audio with various head related transfer functions and to allow for changing head related transfer functions depending on the user's position or orientation. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Billinghurst System does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

### 15. AAR system with MARA Headset ("Gamper AAR System")

The chart attached hereto as Exhibit B-15 provides examples of where Gamper AAR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '628 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Gamper AAR System does not anticipate and/or render obvious the Asserted Claims of the '628 Patent on its own, it would have been obvious to combine or modify Gamper AAR System with concepts from other prior art references and products identified in Sections IV.J.1, 2, 6, 9-10, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '628 Patent are not disclosed and/or rendered obvious by Gamper AAR System and/or Gamper AAR System and such references, the Asserted Claims of the '628 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '628 Patent goes beyond



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combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.16. In addition, it was well understood that providing the user with an image representation of the participant(s) in a virtual teleconference would improve the user's immersion and ability to focus on specific speakers.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to add images or avatars as representations of conference participants. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Gamper AAR System does not disclose one or more limitations of the Asserted Claims of the '628 Patent.

### C. The '090 Patent

As further explained below and in Exhibits C-01 to C-17, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the '090 Patent under 35 U.S.C. § 102 and/or § 103:

- Ballas 439, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 3, 4, 8, and/or 10-12, and/or Section IV.C, for example and without limitation (i) Ballas 439 and Li 305 and Curry, (ii) Ballas 439 and Li 305 and Andrea, (iii) Ballas 439 and Knappe and Curry, (iv) Ballas 439 and Knappe and Andrea, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.



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- Bedingfield, alone or in view of one or more of the prior art references and products identified in Section IV.J. 1, 2, 3, 8, and/or 10-12, or Section IV.C, for example and without limitation (i) Bedingfield in view of Andrea, (ii) Bedingfield and Hammershoi and Curry, (iii) Bedingfield and Knappe and Curry, (iv) Bedingfield and Knappe and Andrea, (v) Bedingfield in view of Ballas 123 which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Begault 2000 alone or in view of one or more of the prior art references and products identified in Sections IV.J. 1, 10, and/or 12, and/or Section IV.C, for example and without limitation (i) Begault 2000 and Li 305 and Curry, (ii) Begault 2000 and Li 305 and Andrea, (iii) Begault 2000 and Hammershoi and Curry, (iv) Begault 2000 and Hammershoi and Andrea, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Boustead alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 4, 8, and/or 11, and/or Section IV.C, for example and without limitation (i) Boustead and Curry and Hammershoi, (ii) Boustead and Curry and Knappe, (iii) Boustead and Andrea and Hammershoi, (iv) Boustead and Andrea and Knappe, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Curry alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 3, and/or 8, and/or Section IV.C, for example and without limitation (i) Curry and Ballas 439 and Li 305, (ii) Curry and Ballas 439 and Knappe, (iii) Curry and Bedingfield and Hammershoi, (iv) Curry and Boustead and Hammershoi, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- CU-SeeMe VR System alone or in view of one or more of the prior art references and products identified in Section IV.J. 1-4, 8, and/or 11-12, and/or Section IV.C, for example and without limitation (i) CU-SeeMe VR System and Ballas 439 and Andrea and Knappe, (ii) CU-SeeMe VR System and Ballas 439 and Curry and Knappe, (iii) CU-SeeMe VR System and Pedersen and Andrea, (iv) CU-SeeMe VR System and Pedersen and Curry, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Etter 419 alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 3, 4, 8, and/or 10-12, and/or Section IV.C, for example and without limitation (i) Etter 419 and Hammershoi and Curry and Cohen 1991 II, (ii) Etter 419 and Hammershoi and Curry and Jarvinen, (iii) Etter 419 and Knappe and Curry, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Gardner alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 4, 8, and/or 11, and/or Section IV.C, for example and without limitation (i) Gardner and Bedingfield and Andrea and Hammershoi, (ii) Gardner and Bedingfield and Andrea and Knappe, (iii) Gardner and Pedersen and Andrea, (iv) Gardner and Pedersen and Curry, which a POSA would have known and



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been motivated to combine for at least the reasons explained in the following subsections.

- Hammershoi alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 10, and/or 12, and/or Section IV.C, for example and without limitation (i) Hammershoi and Bedingfield and Andrea, (ii) Hammershoi and Bedingfield and Curry, (iii) Hammershoi and Boustead and Curry, (iv) Hammershoi and Boustead and Andrea, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Jarvinen alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 4, 8, 10, and/or 12, and/or Section IV.C, for example and without limitation (i) Jarvinen and Hammershoi and Andrea, (ii) Jarvinen and Hammershoi and Curry, (iii) Jarvinen and Pedersen and Andrea, (iv) Jarvinen and Pedersen and Curry, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Knappe, alone or in view of one or more of the prior art references and products identified in Sections IV.J. IV.J.1, 2, 3, and/or 4, and/or Section IV.C, for example and without limitation (i) Knappe and Ballas 439 and Curry, (ii) Knappe and Ballas 439 and Andrea, (iii) Knappe and Boustead and Curry, (iv) Knappe and Boustead and Andrea, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Li 305 alone or in view of one or more of the prior art references and products identified in Section IV.J.1, 2, 4, and/or 10-12, and/or Section IV.C, for example and without limitation (i) Li 305 and Ballas 439 and Curry, (ii) Li 305 in view of Andrea, (iii) Li 305 and Begault 2000 and Curry, (iv) Li 305 and Begault 2000 and Andrea, (v) Li 305 in view of Ballas 123 which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedersen, alone or in view of one or more of the prior art references and products identified in Section IV.J.10, and/or 12, and/or Section IV.C, for example and without limitation (i) Pedersen and Jarvinen and Curry, (ii) Pedersen and Jarvinen and Andrea, (iii) Pedersen and Gardner and Andrea, (iv) Pedersen and Gardner and Curry, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Andrea alone or in view of one or more of the prior art references and products identified in Sections IV.J. 1, 2, 3, 4, 6, 8, 9-10, and/or 12, and/or Section IV.C, for example and without limitation (i) Andrea and Bedingfield and Knappe, (ii) Andrea and Bedingfield and Hammershoi, (iii) Andrea and Boustead and Knappe, (iv) Andrea and Boustead and Hammershoi, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Billinghurst System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 8, and/or 11-12, and/or Section IV.C, for example and without limitation (i) Billinghurst System and Curry and Pedersen, (ii) Billinghurst System and Andrea and Pedersen, (iii) Billinghurst System and Curry and Begault 2000, (iv) Billinghurst System and Andrea and Begault 2000, which a POSA



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would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Gamper AAR System alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3, 8, 10, and/or 12, and/or Section IV.C, for example and without limitation (i) Gamper AAR System and Bedingfield, (ii) Gamper AAR System and Curry and Jarvinen, (iii) Gamper AAR System and Cohen 1991 II, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Cohen 1991 II alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 8, and/or 11, and/or Section IV.C, for example and without limitation (i) Cohen 1991 II and Gamper AAR System, (ii) Cohen 1991 II and Andrea, (iii) Cohen 1991 II and Curry which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections

### 1. U.S. Patent No. 6,961,439 ("Ballas 439")

The chart attached as Exhibit C-01 provides examples of where Ballas 439 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ballas 439 does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Ballas 439 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 3, 4, 8, and/or 10-12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Ballas 439 and/or Ballas 439 and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.1. For example, the prior art taught adapting



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binaural audio to a user based on interaural time difference of the user's ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as it was a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ballas 439 does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**2. U.S. Patent No. 9,632,683 ("Jarvinen")**

The chart attached as Exhibit C-02 provides examples of where Jarvinen discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Jarvinen does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Jarvinen with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, 4, 8, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Jarvinen and/or Jarvinen and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between



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clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.2. For example, the prior art taught adapting binaural audio to a user based on interaural time difference of the user's ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as it was a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Jarvinen does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

### 3. U.S. Patent No. 9,307,331 ("Pedersen")

The chart attached as Exhibit C-03 provides examples of where Pedersen discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Pedersen does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Pedersen with concepts and features disclosed in other prior art references and products identified in Sections IV.J.10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Pedersen and/or Pedersen and such references, the Asserted Claims of the '090 Patent are



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nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.3.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedersen does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**4. U.S. Patent Pub. No. 2010/0328419 ("Etter 419")**

The chart attached as Exhibit C-04 provides examples of where Etter 419 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Etter 419 does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Etter 419 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 3, 4, 8, and/or 10-12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Etter 419 and/or Etter 419 and such references, the Asserted Claims of the '090 Patent



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are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.4. For example, a POSA would have known and been motivated to adapt binaural audio based on interaural time difference of the user's ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as it was a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Etter 419 does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**5. U.S. Patent No. 8,406,439 ("Bedingfield")**

The chart attached as Exhibit C-05 provides examples of where Bedingfield discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Bedingfield does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Bedingfield with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 3, 8, and/or 10-12, or



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similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Bedingfield and/or Bedingfield and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.5. A POSA would have known and been motivated to adapt binaural audio based on interaural time difference of the user's ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as such techniques would be a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Bedingfield does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**6. U.S. Patent Pub. No. 2009/0052703 ("Hammershoi")**

The chart attached as Exhibit C-06 provides examples of where Hammershoi discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus



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anticipates those claims and/or renders those claims obvious. In addition, to the extent Hammershoi does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Hammershoi with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Hammershoi and/or Hammershoi and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.6.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Hammershoi does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**7. 3-D Sound for Virtual Reality and Multimedia ("Begault 2000")**

The chart attached as Exhibit C-07 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus



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anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault 2000 does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.7.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**8. U.S. Patent No. 9,961,208 ("Boustead")**

The chart attached as Exhibit C-08 provides examples of where Boustead discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus



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anticipates those claims and/or renders those claims obvious. In addition, to the extent Boustead does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Boustead with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, 4, 8, and/or 11, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Boustead and/or Boustead and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.9. For example, it was well-known to adapt binaural audio based on interaural time difference of the user's ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as such techniques would be a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with



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additional positions on obviousness in response to any allegation by Plaintiff that Boustead does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

**9. U.S. Patent No. 6,850,496 (“Knappe”)**

The chart attached as Exhibit C-09 provides examples of where Knappe discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Knappe does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Knappe with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 3, and/or 4, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by Knappe and/or Knappe and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.10.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with



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additional positions on obviousness in response to any allegation by Plaintiff that Knappe does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

**10. U.S. Patent No. 9,131,305 (“Li 305”)**

The chart attached as Exhibit C-10 provides examples of where Li 305 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Li 305 does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Li 305 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 4, and/or 10-12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by Li 305 and/or Li 305 and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.11.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with



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additional positions on obviousness in response to any allegation by Plaintiff that Li 305 does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

### 11. U.S. Patent No. 8,559,646 (“Gardner”)

chart attached as Exhibit C-11 provides examples of where Gardner discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Gardner does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Gardner with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, 4, 8, and/or 11, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by Gardner and/or Gardner and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.8. For example, the prior art taught techniques to adapt binaural audio based on interaural time difference of the user’s ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as such



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techniques would be a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Gardner does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

**12. U.S. Patent No. 7,012,630 (“Curry”)**

The chart attached as Exhibit C-12 provides examples of where Curry discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Curry does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Curry with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by Curry and/or Curry and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. It was well-known that spatial audio during a telephone call (i.e., conference calls or teleconferences) commonly process binaural audio with



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HRTFs. It was also well-known that spatialized audio increases the comprehensibility of one or more speakers and enhances a participant's ability to listen to a specific speaker when multiple persons are talking. This also aids in the identification of a speaker by using spatial location cues, and to decrease the perception of background noise.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to improve spatial audio during a telephone call based on the well-known techniques of convolving binaural audio with HRTFs. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Curry does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

### 13. U.S. Patent No. 8,818,000 (“Andrea”)

The chart attached as Exhibit C-13 provides examples of where Andrea discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Andrea does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Andrea with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 3, 4, 6, 8, 9-10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by Andrea and/or Andrea and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes



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patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the references use well-known techniques to generate binaural audio for spatial communication between participants in a telephone call. Additionally, the prior art teaches that spatialized audio improves the ability for users to experience the surrounding environment when using the systems such as those described in Andrea. Additionally, it was well understood that spatial audio contributes to realistic perception of a three dimensional virtual environment. Furthermore, it was also well-known that it was desirable to change the HRTF filters as the user moved in order to maintain a realistic auditory environment. Using well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, would, therefore, increase sensory capabilities of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. For example, a POSA would have known and been motivated to improve spatial audio during a telephone call based on well-known techniques of processing binaural audio. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Andrea does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

### 14. CU SeeMe VR (“CU-SeeMe VR System”)

The chart attached as Exhibit C-15 provides examples of where CU-SeeMe VR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent CU-SeeMe VR System does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify CU-SeeMe VR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-4, 8, and/or 11-12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by CU-SeeMe VR System and/or CU-SeeMe VR System and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.14. For example, the prior art taught techniques to adapt binaural audio based on interaural time difference of the user’s ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based



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on an interaural time difference for use with spatial audio during a telephone call as such techniques would be a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the CU-SeeMe VR System does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

### 15. Wearable Spatial Conferencing Space system with Virtual i-O Glasses (“Billinghurst System”)

The chart attached as Exhibit C-14 provides examples of where Billinghurst System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Billinghurst System does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Billinghurst System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, 8, and/or 11-12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’090 Patent are not disclosed and/or rendered obvious by Billinghurst System and/or Billinghurst System and such references, the Asserted Claims of the ’090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.15. For example, the prior art taught



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techniques to adapt binaural audio based on interaural time difference of the user's ears.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as such techniques would be a commonplace and predictable way to create a more immersive and enjoyable audio experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Billinghurst System does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

**16. AAR system with MARA Headset ("Gamper AAR System")**

The chart attached as Exhibit C-16 provides examples of where Gamper AAR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Gamper AAR System does not anticipate and/or render obvious the Asserted Claims of the '090 Patent on its own, it would have been obvious to combine or modify Gamper AAR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3, 8, 10, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Gamper AAR System and/or Gamper AAR System and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the



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’090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, the reasons discussed above in Section IV.A.16. Additionally, commonplace and well-understood wearable electronic devices are used to provide spatial audio during a telephone call. For example, providing the remote and/or local user(s) with a wearable electronic device equipped with one or more microphones capable of recording binaural audio in combination with Gamper AAR System is one well-known and predictable way to provide spatial audio.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to have remote participants also use wearable electronic devices, such as Gamper AAR System. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Gamper AAR System does not disclose one or more limitations of the Asserted Claims of the ’090 Patent.

### 17. Multidimensional Audio Windows: Extending User Interfaces Through the Use of Spatial Auditory Information (“Cohen 1991 II”)

The chart attached as Exhibit C-17 provides examples of where Cohen 1991 II discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’090 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Cohen 1991 II does not anticipate and/or render obvious the Asserted Claims of the ’090 Patent on its own, it would have been obvious to combine or modify Cohen 1991 II with concepts and features



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disclosed in other prior art references and products identified in Sections IV.J.4, 8, and/or 11, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '090 Patent are not disclosed and/or rendered obvious by Cohen 1991 II and/or Cohen 1991 II and such references, the Asserted Claims of the '090 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '090 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to systems and methods for communication using spatialized audio, or teleconferencing systems. For example, the prior art taught adapting binaural audio to a user based on interaural time difference of the user's ears. Additionally, the provision of spatial audio during telephone calls utilizes well-known techniques, including, for example, tracking the orientation of users' heads or users' positions and adjusting binaural audio from sound sources accordingly. The prior art teaches techniques for this, such as attaching a sensor to a wearable electronic device, or receiving signals from devices located at the user's ears. Additionally, head tracking and spatialized audio allows for rich manipulation of an audio scene because each audio object may be individually manipulated. In particular, by using these well-known techniques taught in the prior art a user may increase the loudness of certain audio objects over others in a natural and intuitive way. A POSA would have known and been motivated to use the well-known techniques for spatializing multiple audio sources, such as those described in the references in Section IV.J, to increase user interactivity and manipulation of audio objects within an audio scene. Additionally, the known solutions disclosed in many prior art references were



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often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to adjust binaural audio based on an interaural time difference for use with spatial audio during a telephone call as it was a commonplace and predictable way to create a more immersive and enjoyable audio experience. Additionally, a POSA would have known and been motivated to track users' head orientation to adjust spatial audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Cohen 1991 II does not disclose one or more limitations of the Asserted Claims of the '090 Patent.

### D. The '184 Patent

As further explained below and in Exhibits D-01 to D-12, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claim of the '184 Patent under 35 U.S.C. § 102 and/or § 103:

- Jang, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Jang and Clement and Sauk 903, (ii) Jang and Sawyer and Sauk 903, (iii) Jang and Kraver and Sauk 903, (iv) Jang and Ashforth and Sauk 903, and (v) Jang and Pedrotti and Sauk 903, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Clement, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Clement with Osman, alone or in view of Sauk 903, (ii) Clement and Srinivasan, and Sauk 903 and/or Jang, (iii) Clement and Begault 2000, and Sauk 903 and/or Jang,



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(iv) and Clement and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Sawyer, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Sawyer and Osman, and Sauk 903 and/or Jang, (ii) Sawyer and Srinivasan, and Sauk 903 and/or Jang, (iii) Sawyer and Begault 2000, and Sauk 903 and/or Jang, (iv) and Sawyer and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Kraver, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Kraver and Osman, and Sauk 903 and/or Jang, (ii) Kraver and Srinivasan, and Sauk 903 and/or Jang, (iii) Kraver and Begault 2000, and Sauk 903 and/or Jang, (iv) and Kraver and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Ashforth, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Ashforth and Osman, and Sauk 903 and/or Jang, (ii) Ashforth and Srinivasan, and Sauk 903 and/or Jang, (iii) Ashforth and Begault 2000, and Sauk 903 and/or Jang, (iv) and Ashforth and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Zhou, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Zhou and Clement and Sauk 903 and/or Jang, (ii) Zhou and Sawyer, and Sauk 903 and/or Jang, (iii) Zhou and Kraver, and Sauk 903 and/or Jang, (iv) Zhou and Ashforth, and Sauk 903 and/or Jang, and (v) Zhou and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- HTC Vive System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or 12, and/or Section IV.D, for example and without limitation (i) HTC Vive System and Clement and Sauk 903 and/or Jang, (ii) HTC Vive System and Sawyer, and Sauk 903 and/or Jang, (iii) HTC Vive System and Kraver, and Sauk 903 and/or Jang, (iv) HTC Vive System and Ashforth, and Sauk 903 and/or Jang, and (v) HTC Vive System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- NASA VIEW System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or 12, and/or Section IV.D, for example and without limitation (i) NASA VIEW System and Clement and Sauk 903 and/or Jang, (ii) NASA VIEW System and Sawyer, and Sauk 903 and/or Jang, (iii) NASA VIEW



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System and Kraver, and Sauk 903 and/or Jang, (iv) NASA VIEW System and Ashforth, and Sauk 903 and/or Jang, and (v) NASA VIEW System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Oculus Rift System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or 12, and/or Section IV.D, for example and without limitation (i) Oculus Rift System and Clement and Sauk 903 and/or Jang, (ii) Oculus Rift System and Sawyer, and Sauk 903 and/or Jang, (iii) Oculus Rift System and Kraver, and Sauk 903 and/or Jang, (iv) Oculus Rift System and Ashforth, and Sauk 903 and/or Jang, and (v) Oculus Rift System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sony PSVR System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or 12, and/or Section IV.D, for example and without limitation (i) Sony PSVR System and Clement and Sauk 903 and/or Jang, (ii) Sony PSVR System and Sawyer, and Sauk 903 and/or Jang, (iii) Sony PSVR System and Kraver, and Sauk 903 and/or Jang, (iv) Sony PSVR System and Ashforth, and Sauk 903 and/or Jang, and (v) Sony PSVR System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Microsoft HoloLens System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or 12, and/or Section IV.D, for example and without limitation (i) Microsoft HoloLens System and Clement and Sauk 903 and/or Jang, (ii) Microsoft HoloLens System and Sawyer, and Sauk 903 and/or Jang, (iii) Microsoft HoloLens System and Kraver, and Sauk 903 and/or Jang, (iv) Microsoft HoloLens System and Ashforth, and Sauk 903 and/or Jang, and (v) Microsoft HoloLens System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedrotti, in view of one or more of the prior art references and products identified in Sections IV.J.6-8, and/or Section IV.D, for example and without limitation (i) Pedrotti with Sirinivasan, alone or in view of Sauk 903, (ii) Pedrotti and Osman, and Sauk 903 and/or Jang, (iii) Pedrotti and Begault 2000, and Sauk 903 and/or Jang, (iv) and Pedrotti and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

#### 1. U.S. Patent No. 8,520,872 ("Jang")

The chart attached as Exhibit D-01 provides examples of where Jang discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Jang does not anticipate



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and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify Jang with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Jang and/or Jang and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location,



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or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Jang does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

**2. U.S. Patent No. 9,690,374 ("Clement")**

The chart attached as Exhibit D-02 provides examples of where Clement discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Clement does not



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anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify Clement with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Clement and/or Clement and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers,



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accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Clement does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

### 3. U.S. Patent Pub. No. 2016/0124502 ("Sawyer")

The chart attached as Exhibit D-03 provides examples of where Sawyer discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Sawyer does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have



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been obvious to combine or modify Sawyer with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Sawyer and/or Sawyer and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers,



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accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sawyer does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

**4. U.S. Patent No. 10,725,297 ("Kraver")**

The chart attached as Exhibit D-04 provides examples of where Kraver discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Kraver does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have



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been obvious to combine or modify Kraver with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Kraver and/or Kraver and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers,



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accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Kraver does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

**5. U.K. Patent Pub. No. GB2524269A ("Ashforth")**

The chart attached as Exhibit D-05 provides examples of where Ashforth discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Ashforth does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have



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been obvious to combine or modify Ashforth with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Ashforth and/or Ashforth and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers,



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accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ashforth does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

### 6. Zhou et al., An experimental study on the role of 3D sound in augmented reality environment ("Zhou")

The chart attached as Exhibit D-06 provides examples of where Zhou discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Zhou does not anticipate



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and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify Zhou with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Zhou and/or Zhou and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers,



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accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Zhou does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

**7. HTC Vive System ("HTC Vive System")**

The chart attached as Exhibit D-07 provides examples of where the HTC Vive System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the HTC Vive System does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its



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own, it would have been obvious to combine or modify the HTC Vive System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by the HTC Vive System and/or the HTC Vive System and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers,



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accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the HTC Vive System does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

### 8. NASA Virtual Interface Environment Workstation System ("NASA VIEW System")

The chart attached as Exhibit D-08 provides examples of where the NASA VIEW System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the NASA



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VIEW System does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify the NASA VIEW System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by the NASA VIEW System and/or the NASA VIEW System and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location,



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or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the NASA VIEW System does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

**9. Oculus Rift System ("Oculus Rift System")**

The chart attached as Exhibit D-09 provides examples of where the Oculus Rift System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the Oculus



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Rift System does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify the Oculus Rift System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by the Oculus Rift System and/or the Oculus Rift System and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location,



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or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the Oculus Rift System does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

### 10. Sony Playstation VR System ("Sony PSVR System")

The chart attached as Exhibit D-10 provides examples of where the Sony PSVR System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the Sony



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PSVR System does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify the Sony PSVR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by the Sony PSVR System and/or the Sony PSVR System and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track



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the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the Sony PSVR System does not disclose one or more limitations of the Asserted Claim of the '184 Patent.

### 11. Microsoft HoloLens System ("Microsoft HoloLens System")

The chart attached as Exhibit D-11 provides examples of where the Microsoft HoloLens System discloses, either expressly or inherently, each limitation of the Asserted Claim of the



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‘184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the Microsoft HoloLens System does not anticipate and/or render obvious the Asserted Claim of the ‘184 Patent on its own, it would have been obvious to combine or modify the Microsoft HoloLens System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the ‘184 Patent is not disclosed and/or rendered obvious by the Microsoft HoloLens System and/or the Microsoft HoloLens System and such references, the Asserted Claim of the ‘184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the ‘184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the



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extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the Microsoft HoloLens System does not disclose one or more limitations of the Asserted Claim of the ‘184 Patent.



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### 12. U.S. Patent No. 9,851,786 ("Pedrotti")

The chart attached as Exhibit D-12 provides examples of where Pedrotti discloses, either expressly or inherently, each limitation of the Asserted Claim of the '184 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Pedrotti does not anticipate and/or render obvious the Asserted Claim of the '184 Patent on its own, it would have been obvious to combine or modify Pedrotti with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '184 Patent is not disclosed and/or rendered obvious by Pedrotti and/or Pedrotti and such references, the Asserted Claim of the '184 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '184 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry



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about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedrotti does not disclose one or more limitations of the Asserted Claim of the ‘184 Patent.



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### E. The ’179 Patent

As further explained below and in Exhibits E-01 to E-12, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claim of the ’179 Patent under 35 U.S.C. § 102 and/or § 103:

- Clement, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or IV.J.8, and/or Section IV.E, for example and without limitation (i) Clement with Osman, alone or in view of Sauk 903, (ii) Clement and Srinivasan, and Sauk 903 and/or Jang, (iii) Clement and Begault 2000, and Sauk 903 and/or Jang, (iv) and Clement and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Ashforth, alone or in view of one or more of the prior art references and products identified in Sections IV.J.6, 7, and/or IV.J.8, and/or Section IV.E, for example and without limitation (i) Ashforth and Osman, and Sauk 903 and/or Jang, (ii) Ashforth and Srinivasan, and Sauk 903 and/or Jang, (iii) Ashforth and Begault 2000, and Sauk 903 and/or Jang, (iv) and Ashforth and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Jang, alone or in view of one or more of the prior art references and products identified in IV.J.6, 7, and/or IV.J.8, and/or Section IV.E, for example and without limitation (i) Jang and Clement and Sauk 903, (ii) Jang and Sawyer and Sauk 903, (iii) Jang and Kraver and Sauk 903, (iv) Jang and Ashforth and Sauk 903, and (v) Jang and Pedrotti and Sauk 903, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Kraver, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, and/or 7, and/or Section IV.E, for example and without limitation (i) Kraver and Osman, and Sauk 903 and/or Jang, (ii) Kraver and Srinivasan, and Sauk 903 and/or Jang, (iii) Kraver and Begault 2000, and Sauk 903 and/or Jang, (iv) and Kraver and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sawyer, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or IV.J.8, and/or Section IV.E, for example and without limitation (i) Sawyer and Osman, and Sauk 903 and/or Jang, (ii) Sawyer and Srinivasan, and Sauk 903 and/or Jang, (iii) Sawyer and Begault 2000, and Sauk 903 and/or Jang, (iv) and Sawyer and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.



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- Zhou, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or IV.J.8, and/or Section IV.E, for example and without limitation (i) Zhou and Clement and Sauk 903 and/or Jang, (ii) Zhou and Sawyer, and Sauk 903 and/or Jang, (iii) Zhou and Kraver, and Sauk 903 and/or Jang, (iv) Zhou and Ashforth, and Sauk 903 and/or Jang, and (v) Zhou and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- HTC Vive System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or IV.J.12, and/or Section IV.E, for example and without limitation (i) HTC Vive System and Clement and Sauk 903 and/or Jang, (ii) HTC Vive System and Sawyer, and Sauk 903 and/or Jang, (iii) HTC Vive System and Kraver, and Sauk 903 and/or Jang, (iv) HTC Vive System and Ashforth, and Sauk 903 and/or Jang, and (v) HTC Vive System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- NASA VIEW System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or IV.J.12, and/or Section IV.E, for example and without limitation (i) NASA VIEW System and Clement and Sauk 903 and/or Jang, (ii) NASA VIEW System and Sawyer, and Sauk 903 and/or Jang, (iii) NASA VIEW System and Kraver, and Sauk 903 and/or Jang, (iv) NASA VIEW System and Ashforth, and Sauk 903 and/or Jang, and (v) NASA VIEW System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Oculus Rift System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or IV.J.12, and/or Section IV.E, for example and without limitation (i) Oculus Rift System and Clement and Sauk 903 and/or Jang, (ii) Oculus Rift System and Sawyer, and Sauk 903 and/or Jang, (iii) Oculus Rift System and Kraver, and Sauk 903 and/or Jang, (iv) Oculus Rift System and Ashforth, and Sauk 903 and/or Jang, and (v) Oculus Rift System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sony PSVR System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or IV.J.12, and/or Section IV.E, for example and without limitation (i) Sony PSVR System and Clement and Sauk 903 and/or Jang, (ii) Sony PSVR System and Sawyer, and Sauk 903 and/or Jang, (iii) Sony PSVR System and Kraver, and Sauk 903 and/or Jang, (iv) Sony PSVR System and Ashforth, and Sauk 903 and/or Jang, and (v) Sony PSVR System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Microsoft HoloLens System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or IV.J.12, and/or Section IV.E, for example and without limitation (i) Microsoft HoloLens System and Clement and Sauk 903 and/or Jang, (ii) Microsoft HoloLens System and Sawyer, and Sauk 903



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and/or Jang, (iii) Microsoft HoloLens System and Kraver, and Sauk 903 and/or Jang, (iv) Microsoft HoloLens System and Ashforth, and Sauk 903 and/or Jang, and (v) Microsoft HoloLens System and Pedrotti, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Pedrotti, alone or in view of one or more of the prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or IV.J.8, and/or Section IV.E, for example and without limitation (i) Pedrotti with Sirinivasan, alone or in view of Sauk 903, (ii) Pedrotti and Osman, and Sauk 903 and/or Jang, (iii) Pedrotti and Begault 2000, and Sauk 903 and/or Jang, (iv) and Pedrotti and Zhou, and Sauk 903 and/or Jang, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

#### 1. U.S. Patent No. 9,690,374 ("Clement")

The chart attached as Exhibit E-1 provides examples of where Clement discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Clement does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Clement with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Clement and/or Clement and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not goes beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Clement does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**2. U.K. Patent Pub. No. GB2524269A ("Ashforth")**

The chart attached as Exhibit E-02 provides examples of where Ashforth discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Ashforth does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Ashforth with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Ashforth and/or Ashforth and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not goes beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ashforth does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**3. U.S. Patent No. 8,520,872 ("Jang")**

The chart attached as Exhibit E-03 provides examples of where Jang discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Jang does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Jang with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Jang and/or Jang and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not goes beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA..

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Jang does not disclose one or more limitations of the Asserted Claim of the '179 Patent

**4. U.S. Patent Pub. No. 2016/0124502 ("Sawyer")**

The chart attached as Exhibit E-04 provides examples of where Sawyer discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Sawyer does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Sawyer with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Sawyer and/or Sawyer and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not goes beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sawyer does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**5. U.S. Patent No. 10,725,297 ("Kraver")**

The chart attached as Exhibit E-05 provides examples of where Kraver discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Kraver does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Kraver with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Kraver and/or Kraver and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not goes beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Kraver does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

### 6. Zhou et al., An experimental study on the role of 3D sound in augmented reality environment ("Zhou")

The chart attached as Exhibit E-06 provides examples of where Zhou discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Zhou does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Zhou with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Zhou and/or Zhou and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Zhou does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**7. HTC Vive System ("HTC Vive System")**

The chart attached as Exhibit E-07 provides examples of where the HTC Vive System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the HTC Vive System does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify the HTC Vive System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by the HTC Vive System and/or the HTC Vive System and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a



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POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the HTC Vive System does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

### 8. NASA Virtual Interface Environment Workstation System ("NASA VIEW System")

The chart attached as Exhibit E-08 provides examples of where the NASA VIEW System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the NASA VIEW System does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify the NASA VIEW System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by the NASA VIEW System and/or the NASA VIEW System and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both



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virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio



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experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the NASA VIEW System does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**9. Oculus Rift System ("Oculus Rift System")**

The chart attached as Exhibit E-09 provides examples of where the Oculus Rift System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the Oculus Rift System does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify the Oculus Rift System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by the Oculus Rift System and/or the Oculus Rift System and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both



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virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio



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experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the Oculus Rift System does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**10. Sony Playstation VR System ("Sony PSVR System")**

The chart attached as Exhibit E-10 provides examples of where the Sony PSVR System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the Sony PSVR System does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify the Sony PSVR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by the Sony PSVR System and/or the Sony PSVR System and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for



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example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable



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results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the Sony PSVR System does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**11. Microsoft HoloLens System ("Microsoft HoloLens System")**

The chart attached as Exhibit E-11 provides examples of where the Microsoft HoloLens System discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent the Microsoft HoloLens System does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify the Microsoft HoloLens System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, 8, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by the Microsoft HoloLens System and/or the Microsoft HoloLens System and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not go beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear alternatives known to a POSA.



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The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious to try and predictable, and they would have been the result of combining well-known and well-



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understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that the Microsoft HoloLens System does not disclose one or more limitations of the Asserted Claim of the '179 Patent.

**12. U.S. Patent No. 9,851,786 ("Pedrotti")**

The chart attached as Exhibit E-12 provides examples of where Pedrotti discloses, either expressly or inherently, each limitation of the Asserted Claim of the '179 Patent and thus anticipates that claim and/or renders it obvious. In addition, to the extent Pedrotti does not anticipate and/or render obvious the Asserted Claim of the '179 Patent on its own, it would have been obvious to combine or modify Pedrotti with concepts and features disclosed in other prior art references and products identified in Sections IV.J.4, 5, 6, 7, and/or 8, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claim of the '179 Patent is not disclosed and/or rendered obvious by Pedrotti and/or Pedrotti and such references, the Asserted Claim of the '179 Patent is nevertheless unpatentable as obvious because it contains nothing that constitutes patentable innovation—the Asserted Claim of the '179 Patent does not goes beyond combining familiar elements according to known methods to achieve predictable results, or do more than choose between clear



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alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. As also taught in the prior art, providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. In addition, the references use well-known techniques for audio alerts, such as reducing volume or altering the binaural audio in order to better signify the relevancy of the alert. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claim would have been obvious



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to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, to track the user in relation to those boundaries based on a variety of techniques, and to provide the most effective alert once those boundaries are crossed. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedrotti does not disclose one or more limitations of the Asserted Claim of the ’179 Patent.

### F. The ’737 Patent

As further explained below and in Exhibits F-01 to F-14, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the ’737 Patent:

- Osman, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-5, and/or Section IV.F, for example and without limitation (i) Osman and Pedrotti and Flaks 968, including in view of Second Life, (ii) Osman and Ashforth and Wan, including in view of Second Life, (iii) Osman and Sawyer, including in view of Second Life, (iv) Osman and Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sawyer, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, and/or Section IV.F, for example and without limitation (i) Sawyer and Wan and Gorzel, including in view of Second Life, (ii) Sawyer and Wan and Lovitt and Flaks 968, including in view of Second Life, (iii) Sawyer and Wan and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iv) Sawyer and Jang and Flaks 968, including in view of Begault 2000 and/or



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Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Lovitt, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-5, and/or Section IV.F, for example and without limitation (i) Lovitt and Pedrotti and Flaks 968, including in view of Second Life, (ii) Lovitt and Ashforth and Wan, including in view of Second Life, (iii) Lovitt and Sawyer, including in view of Second Life, (iv) Lovitt and Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Katz 031, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-6, and/or Section IV.F, for example and without limitation (i) Katz 031 and Flaks 068 and Pedrotti, including in view of Second Life, (ii) Katz 031 and Wan and Gorzel and Sawyer, including in view of Second Life, (iii) Katz 031 and Lovitt and Ashforth, including in view of Second Life, (iv) Katz 031 and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Ashforth, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, and/or Section IV.F, for example and without limitation (i) Ashforth and Jang, including in view of Begault 2000 and/or Second Life, (ii) Ashforth and Wan and and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iii) Ashforth and Wan and Gorzel, including in view of Second Life,, (iv) Ashforth and Lovitt and Flaks 968, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Balachandreswaran, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-6, and/or Section IV.F, for example and without limitation (i) Balachandreswaran and Flaks 068 and Pedrotti, including in view of Second Life, (ii) Balachandreswaran and Wan and Gorzel and Sawyer, including in view of Second Life, (iii) Balachandreswaran and Lovitt and Ashforth, including in view of Second Life, (iv) Balachandreswaran and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedrotti, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, 6, and/or 12, and/or Section IV.F, for example and without limitation (i) Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, (ii) Pedrotti and Jang and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iii) Pedrotti and Osman and Wan, including in view of Second Life, (iv) Pedrotti and McCulloch, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- McCulloch, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, and/or Section IV.F, for example and



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without limitation (i) McCulloch and Pedrotti, including in view of Second Life, (ii) McCulloch and Ashforth, including in view of Second Life, (iii) McCulloch and Gum, including in view of Second Life, (iv) McCulloch and Sawyer, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Sony PSVR System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, and/or Section IV.F, for example and without limitation (i) Sony PSVR System and Pedrotti and Flaks 968, including in view of Second Life, (ii) Sony PSVR System and Ashforth and Gorzel, including in view of Second Life, (iii) Sony PSVR System and McCulloch, including in view of Lovitt, (iv) Sony PSVR System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- HTC Vive System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 6, and/or 12, and/or Section IV.F, for example and without limitation (i) HTC Vive System and Flaks 968, including in view of Second Life, (ii) HTC Vive System and Wan and Gorzel, including in view of Second Life, (iii) HTC Vive System and Begault 2000, including in view of Second Life, (iv) HTC Vive System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Oculus Rift System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, and/or Section IV.F, for example and without limitation (i) Oculus Rift System and Pedrotti and Flaks 968, including in view of Second Life, (ii) Oculus Rift System and Ashforth and Flaks 968, including in view of Second Life, (iii) Oculus Rift System and McCulloch, including in view of Lovitt, (iv) Oculus Rift System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Microsoft HoloLens System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 5, and/or 12, and/or Section IV.F, for example and without limitation (i) Microsoft HoloLens System and Flaks 968, including in view of Second Life, (ii) Microsoft HoloLens System and Wan and Gorzel, including in view of Second Life, (iii) Microsoft HoloLens System and Begault 2000, including in view of Second Life, (iv) Microsoft HoloLens System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Wu, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-5, and/or 12, and/or Section IV.F, for example and without limitation (i) Wu and Wan and Jang, including in view of Begault 2000 and/or Second Life, (ii) Wu and McCulloch, including in view of Begault 2000 and/or Second Life, (iii) Wu and Wan and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iv) Wu and Pedrotti, including in view of Begault 2000 and/or Second Life, which a POSA



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would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Begault 2000, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-5, and/or 12, and/or Section IV.F, for example and without limitation (i) Begault 2000 and Wan and Jang, including in view of Second Life, (ii) Begault 2000 and McCulloch and Pedrotti, including in view of Second Life, (iii) Begault 2000 and Lovitt and Sawyer, including in view of Second Life, (iv) Begault 2000 and Ashforth and Cohen 1993 I, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

#### 1. U.S. Patent No. 9,037,468 ("Osman")

The chart attached as Exhibit F-01 provides examples of where Osman discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Osman does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Osman with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-5, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Osman and/or Osman and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable



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by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Osman already discloses and teaches position tracking, so a POSA would have been able to leverage Osman's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Additionally, the solutions disclosed in many prior art were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Osman does not disclose one or more limitations of the Asserted Claims of the '737 Patent.



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### 2. U.S. Patent Pub. No. 2016/0124502 ("Sawyer")

The chart attached as Exhibit F-02 provides examples of where Sawyer discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Sawyer does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Sawyer with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Sawyer and/or Sawyer and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within the safety boundaries as discussed in Sawyer. The prior art teaches the use well-known



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techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Sawyer discloses and teaches tracking an "object," which includes the HMD or controller; a POSA would have used the existing tracking system in combination with implementing binaural audio, which requires deriving the user's head position, location, and orientation. Sawyer also discloses and teaches examples of virtual game elements in the Sawyer environment from which sound emanates, which would be the candidates for binaural audio. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sawyer does



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not disclose one or more limitations of the Asserted Claims of the ’737 Patent.

### 3. U.S. Patent Pub. No. 2015/0119130 (“Lovitt”)

The chart attached as Exhibit F-03 provides examples of where Lovitt discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Lovitt does not anticipate and/or render obvious the Asserted Claims of the ’737 Patent on its own, it would have been obvious to combine or modify Lovitt with concepts and features disclosed in other prior art references and products identified in IV.J.1, and/or 3-5, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’737 Patent are not disclosed and/or rendered obvious by Lovitt and/or Lovitt and such references, the Asserted Claims of the ’737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation



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sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Lovitt already discloses and teaches capturing depth information (e.g., structure light depth camera) and positioning systems offering six degrees of freedom, so a POSA would have been able to leverage Lovitt's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Lovitt, in the context of generating binaural audio, discloses a "world space," which a POSA would have known to use as a shared, universal coordinate system on which to map safety boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Lovitt does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

#### 4. U.S. Patent No. 10,095,031 ("Katz 031")

The chart attached as Exhibit F-04 provides examples of where Katz 031 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus



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anticipates those claims and/or renders those claims obvious. In addition, to the extent Katz 031 does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Katz 031 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Katz 031 and/or Katz 031 and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within safety boundaries for the user that define the play area. These safety boundaries alleviate the user's need to worry about or be distracted by the physical



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surroundings or obstacles while being immersed in the extended reality experience. The prior art further teaches techniques for this, such as use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Katz 031 discloses and teaches a VR headset with at least two cameras, multiple position sensors, and an inertial measurement unit, which provides positional and directional information regarding the VR headset; a POSA would have leveraged all of these existing features and hardware to implement safety boundaries for the user and tracking the user's location. Katz 031 further discloses and teaches the VR headset communicating with a console where additional processing can take place, such as additional processing that may be necessary for running an audio engine, visual engine for displaying safety boundaries, or tracking among the VR headset, the VR input interface (such as in the form of a handheld device), and the VR console itself. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either



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the wearable device or the handheld device. Likewise, a POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Katz 031 does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**5. U.K. Patent Appl. No. GB2524269A ("Ashforth")**

The chart attached as Exhibit F-05 provides examples of where Ashforth discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ashforth does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Ashforth with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Ashforth and/or Ashforth and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within safety boundaries as discussed in Ashforth. The prior art further teaches techniques for this, such as the use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Ashforth discloses and teaches communication between the Move controller and the HMD with the games console, where additional processing can take place, such as for tracking among the Move controller, the HMD, and the games console itself. Ashforth further discloses and teaches using the HMD to reproduce audio signals generated by the games console, such that a POSA would have been motivated to modify the generated audio signals to reflect binaural audio, since audio signal generation already occurs at the games console and the Ashforth's system is able to detect the user's physical position. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.



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To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ashforth does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**6. U.S. Patent Pub. No. 2016/0292924 ("Balachandreswaran")**

The chart attached as Exhibit F-06 provides examples of where Balachandreswaran discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Balachandreswaran does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Balachandreswaran with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Balachandreswaran and/or Balachandreswaran and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the



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’737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art further teaches techniques for this, such as the use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Balachandreswaran already discloses and teaches position and orientation tracking using time-of-flight information and laser beams, so a POSA would have been able to leverage Balachandreswaran’s existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. A POSA would have also used the tracking information to implement binaural audio in Balachandreswaran’s system,



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since Balachandreswaran already discloses an audio module with speakers and microphone for audio input and output. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Balachandrewswaran does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**7. U.S. Patent No. 9,851,786 ("Pedrotti")**

The chart attached as Exhibit F-07 provides examples of where Pedrotti discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Pedrotti does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Pedrotti with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, 6, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that



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any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Pedrotti and/or Pedrotti and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Indeed, Pedrotti discloses and teaches tracking the position and orientation of the HMD as well as the position and orientation of one or more trackers in the physical controllers. A POSA would have been able to leverage Pedrotti's existing system and hardware to implement binaural audio, which requires input of positional and orientation information of the user. Pedrotti also discloses and teaches providing audio to the user, e.g., audio warnings. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and



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well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedrotti does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**8. U.S. Patent No. 9,041,622 ("McCulloch")**

The chart attached as Exhibit F-08 provides examples of where McCulloch discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent McCulloch does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify McCulloch with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by McCulloch and/or McCulloch and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, enabling tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within the safety boundaries as discussed in McCulloch. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, McCulloch discloses and teaches that "[u]ser input data is received from a real controller device requesting an action to be performed by the virtual object." Providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. McCulloch discloses and teaches creating a map of the environment, and so a POSA would be motivated to incorporate additional features to notify the user regarding the location with respect to this mapped environment. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either



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the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that McCulloch does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**9. Sony Playstation VR System ("Sony PSVR System")**

The chart attached as Exhibit F-09 provides examples of where Sony PSVR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Sony PSVR System does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Sony PSVR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Sony PSVR System and/or Sony PSVR System and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which



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alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Sony PSVR System already uses head tracking and controller tracking, through positional tracking with LEDs, so a POSA would have been able to leverage Sony PSVR System's existing hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Sony PSVR System's also includes a play area definition feature using external sensors, so a POSA would have been motivated to increase the flexibility of defining the play area by using user input to define the play area. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with



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additional positions on obviousness in response to any allegation by Plaintiff that Sony PSVR System does not disclose one or more limitations of the Asserted Claims of the ’737 Patent.

**10. HTC Vive System (“HTC Vive System”)**

The chart attached as Exhibit F-10 provides examples of where HTC Vive System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent HTC Vive System does not anticipate and/or render obvious the Asserted Claims of the ’737 Patent on its own, it would have been obvious to combine or modify HTC Vive System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 6, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’737 Patent are not disclosed and/or rendered obvious by HTC Vive System and/or HTC Vive System and such references, the Asserted Claims of the ’737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Indeed, HTC Vive System uses a camera-enabled



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Chaperone guidance system, which tracks the position and orientation of the user. HTC Vive System also uses 3D audio processing, but not through a built-in solution. A POSA would have been able to leverage the existing hardware and processing of HTC Vive System to implement binaural audio, which requires input of positional and orientation information of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that HTC Vive System does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**11. Oculus Rift System ("Oculus Rift System")**

The chart attached as Exhibit F-11 provides examples of where Oculus Rift System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Oculus Rift System does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Oculus Rift System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not



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disclosed and/or rendered obvious by Oculus Rift System and/or Oculus Rift System and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Oculus Rift System already uses six degree of freedom rotational and positional tracking, so a POSA would have been able to leverage the existing hardware and processing of Oculus Rift System to implement safety boundaries and tracking the user with respect to those boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.



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To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Moreover, design incentives and other market forces would have prompted those endeavors. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Oculus Rift System does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

**12. Microsoft HoloLens System ("Microsoft HoloLens System")**

The chart attached as Exhibit F-12 provides examples of where Microsoft HoloLens System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Microsoft HoloLens System does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Microsoft HoloLens System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Microsoft HoloLens System and/or Microsoft HoloLens System and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements



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according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Microsoft HoloLens System already uses position tracking, so a POSA would have been able to leverage the existing hardware and processing of Microsoft HoloLens System to implement safety boundaries and tracking the user with respect to those boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries



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for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Microsoft HoloLens System does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

### 13. 3D Audio Interface for Rich Mobile Web Experiences ("Wu")

The chart attached as Exhibit F-13 provides examples of where Wu discloses, either expressly or inherently, each limitation of the Asserted Claims of the '737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Wu does not anticipate and/or render obvious the Asserted Claims of the '737 Patent on its own, it would have been obvious to combine or modify Wu with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '737 Patent are not disclosed and/or rendered obvious by Wu and/or Wu and such references, the Asserted Claims of the '737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example,



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seek to provide the user with a more immersive extended reality experience, which is typically implemented using a head-mounted device or a wearable device that provides an image to the user. Specifically, Wu explains that applications of its described 3D audio interface is not limited to simply audio, but rather enhances mobile web experiences including visual experiences, e.g., YouTube video stream or users playing a virtual board game. A more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Wu discloses and teaches that "calculat[ing] the position of the user" as well as allowing the user to control location in audio space. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to combine the mobile-implemented experience with a head-mounted device or wearable device, enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have



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prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Wu does not disclose one or more limitations of the Asserted Claims of the ’737 Patent.

**14. 3-D Sound for Virtual Reality and Multimedia (“Begault 2000”)**

The chart attached as Exhibit F-14 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’737 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault 2000 does not anticipate and/or render obvious the Asserted Claims of the ’737 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’737 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the ’737 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’737 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience, which is typically implemented using a head-mounted device or a wearable device that provides an image to the user. A more immersive extended reality experience is also achievable by, for example, enabling



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communication and tracking between the wearable device and a handheld device to reduce externalities. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Begault 2000 discloses and teaches that "[s]ensors, hardware such as magnetic or mechanical position trackers, six- degrees-of-freedom trackballs, speech analyzers, and data gloves" for tracking the position of the user for use in producing spatial audio. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable tracking between a wearable device and a handheld device, as well as tracking the user's location through either a wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the '737 Patent.

### G. The '509 Patent

As further explained below and in Exhibits G-01 to G-14, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject



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matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the '509 Patent under 35 U.S.C. § 102 and/or § 103:

- Osman, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-5, and/or Section IV.G, for example and without limitation (i) Osman and Pedrotti and Flaks 968, including in view of Second Life, (ii) Osman and Ashforth and Wan, including in view of Second Life, (iii) Osman and Sawyer, including in view of Second Life, (iv) Osman and Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sawyer, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, and/or Section IV.G, for example and without limitation (i) Sawyer and Wan and Gorzel, including in view of Second Life, (ii) Sawyer and Wan and Lovitt and Flaks 968, including in view of Second Life, (iii) Sawyer and Wan and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iv) Sawyer and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Lovitt, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-5, and/or Section IV.G, for example and without limitation (i) Lovitt and Pedrotti and Flaks 968, including in view of Second Life, (ii) Lovitt and Ashforth and Wan, including in view of Second Life, (iii) Lovitt and Sawyer, including in view of Second Life, (iv) Lovitt and Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Katz 031, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-6, and/or Section IV.G, for example and without limitation (i) Katz 031 and Flaks 068 and Pedrotti, including in view of Second Life, (ii) Katz 031 and Wan and Gorzel and Sawyer, including in view of Second Life, (iii) Katz 031 and Lovitt and Ashforth, including in view of Second Life, (iv) Katz 031 and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Ashforth, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, and/or Section IV.G, for example and without limitation (i) Ashforth and Jang, including in view of Begault 2000 and/or Second Life, (ii) Ashforth and Wan and and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iii) Ashforth and Wan and Gorzel, including in view of Second Life,, (iv) Ashforth and Lovitt and Flaks 968, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.



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- Balachandreswaran, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-6, and/or Section IV.G, for example and without limitation (i) Balachandreswaran and Flaks 068 and Pedrotti, including in view of Second Life, (ii) Balachandreswaran and Wan and Gorzel and Sawyer, including in view of Second Life, (iii) Balachandreswaran and Lovitt and Ashforth, including in view of Second Life, (iv) Balachandreswaran and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedrotti, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, 6, and/or 12 and/or Section IV.G, for example and without limitation (i) Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, (ii) Pedrotti and Jang and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iii) Pedrotti and Osman and Wan, including in view of Second Life, (iv) Pedrotti and McCulloch, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- McCulloch, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, and/or Section IV.G, for example and without limitation (i) McCulloch and Pedrotti, including in view of Second Life, (ii) McCulloch and Ashforth, including in view of Second Life, (iii) McCulloch and Gum, including in view of Second Life, (iv) McCulloch and Sawyer, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sony PSVR System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, and/or Section IV.G, for example and without limitation (i) Sony PSVR System and Pedrotti and Flaks 968, including in view of Second Life, (ii) Sony PSVR System and Ashforth and Gorzel, including in view of Second Life, (iii) Sony PSVR System and McCulloch, including in view of Lovitt, (iv) Sony PSVR System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- HTC Vive System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 6, and/or 12, and/or Section IV.G, for example and without limitation (i) HTC Vive System and Flaks 968, including in view of Second Life, (ii) HTC Vive System and Wan and Gorzel, including in view of Second Life, (iii) HTC Vive System and Begault 2000, including in view of Second Life, (iv) HTC Vive System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Oculus Rift System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, and/or Section IV.G, for example and without limitation (i) Oculus Rift System and Pedrotti and Flaks 968, including in view of Second Life, (ii) Oculus Rift System and Ashforth and Flaks 968, including in



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view of Second Life, (iii) Oculus Rift System and McCulloch, including in view of Lovitt, (iv) Oculus Rift System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Microsoft Hololens System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 5, and/or 12, and/or Section IV.G, for example and without limitation (i) Microsoft HoloLens System and Flaks 968, including in view of Second Life, (ii) Microsoft HoloLens System and Wan and Gorzel, including in view of Second Life, (iii) Microsoft HoloLens System and Begault 2000, including in view of Second Life, (iv) Microsoft HoloLens System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Wu, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-5, and/or 12, and/or Section IV.G, for example and without limitation (i) Wu and Wan and Jang, including in view of Begault 2000 and/or Second Life, (ii) Wu and McCulloch, including in view of Begault 2000 and/or Second Life, (iii) Wu and Wan and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iv) Wu and Pedrotti, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Begault 2000, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-5, and/or 12, and/or Section IV.G, for example and without limitation (i) Begault 2000 and Wan and Jang, including in view of Second Life, (ii) Begault 2000 and McCulloch and Pedrotti, including in view of Second Life, (iii) Begault 2000 and Lovitt and Sawyer, including in view of Second Life, (iv) Begault 2000 and Ashforth and Cohen 1993 I, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

#### 1. U.S. Patent No. 9,037,468 ("Osman")

The chart attached as Exhibit G-01 provides examples of where Osman discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Osman does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Osman with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-5, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that



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any limitation of the Asserted Claims of the ’509 Patent are not disclosed and/or rendered obvious by Osman and/or Osman and such references, the Asserted Claims of the ’509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Osman already discloses and teaches position tracking, so a POSA would have been able to leverage Osman’s existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Additionally, the solutions disclosed in many prior art were often discussed in textbooks and comprehensive guides, such as Jerald.



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To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Osman does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**2. U.S. Patent Pub. No. 2016/0124502 ("Sawyer")**

The chart attached as Exhibit G-02 provides examples of where Sawyer discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Sawyer does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Sawyer with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Sawyer and/or Sawyer and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.



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The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within the safety boundaries as discussed in Sawyer. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Sawyer discloses and teaches tracking an "object," which includes the HMD or controller; a POSA would have used the existing tracking system in combination with implementing binaural audio, which requires deriving the user's head position, location, and orientation. Sawyer also discloses and teaches examples of virtual game elements in the Sawyer environment from which sound emanates, which would be the candidates for binaural audio. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been



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obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sawyer does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**3. U.S. Patent Pub. No. 2015/0119130 ("Lovitt")**

The chart attached as Exhibit G-03 provides examples of where Lovitt discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Lovitt does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Lovitt with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-5, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Lovitt and/or Lovitt and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between



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clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Lovitt already discloses and teaches capturing depth information (e.g., structure light depth camera) and positioning systems offering six degrees of freedom, so a POSA would have been able to leverage Lovitt's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Lovitt, in the context of generating binaural audio, discloses a "world space," which a POSA would have known to use as a shared, universal coordinate system on which to map safety boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and



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well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Lovitt does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

#### 4. U.S. Patent No. 10,095,031 ("Katz 031")

The chart attached as Exhibit G-04 provides examples of where Katz 031 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Katz 031 does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Katz 031 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Katz 031 and/or Katz 031 and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both



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virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within safety boundaries for the user that define the play area. These safety boundaries alleviate the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art further teaches techniques for this, such as use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Katz 031 discloses and teaches a VR headset with at least two cameras, multiple position sensors, and an inertial measurement unit, which provides positional and directional information regarding the VR headset; a POSA would have leveraged all of these existing features and hardware to implement safety boundaries for the user and tracking the user's location. Katz 031 further discloses and teaches the VR headset communicating with a console where additional processing can take place, such as additional processing that may be necessary for running an audio engine, visual engine for displaying safety boundaries, or tracking among the VR headset,



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the VR input interface (such as in the form of a handheld device), and the VR console itself. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Likewise, a POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Katz 031 does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**5. U.K. Patent Appl. No. GB2524269A ("Ashforth")**

The chart attached as Exhibit G-05 provides examples of where Ashforth discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ashforth does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Ashforth with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, or similar



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references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Ashforth and/or Ashforth and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within safety boundaries as discussed in Ashforth. The prior art further teaches techniques for this, such as the use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies.



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Indeed, Ashforth discloses and teaches communication between the Move controller and the HMD with the games console, where additional processing can take place, such as for tracking among the Move controller, the HMD, and the games console itself. Ashforth further discloses and teaches using the HMD to reproduce audio signals generated by the games console, such that a POSA would have been motivated to modify the generated audio signals to reflect binaural audio, since audio signal generation already occurs at the games console and the Ashforth's system is able to detect the user's physical position. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ashforth does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**6. U.S. Patent Pub. No. 2016/0292924 ("Balachandreswaran")**

The chart attached as Exhibit G-06 provides examples of where Balachandreswaran discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent



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and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Balachandreswaran does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Balachandreswaran with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Balachandreswaran and/or Balachandreswaran and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art further teaches techniques for this, such as the use of positioning



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systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Balachandreswaran already discloses and teaches position and orientation tracking using time-of-flight information and laser beams, so a POSA would have been able to leverage Balachandreswaran's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. A POSA would have also used the tracking information to implement binaural audio in Balachandreswaran's system, since Balachandreswaran already discloses an audio module with speakers and microphone for audio input and output. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that



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Balachandrewswaran does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

### 7. U.S. Patent No. 9,851,786 ("Pedrotti")

The chart attached as Exhibit G-07 provides examples of where Pedrotti discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Pedrotti does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Pedrotti with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, 6, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Pedrotti and/or Pedrotti and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Indeed, Pedrotti discloses and teaches tracking



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the position and orientation of the HMD as well as the position and orientation of one or more trackers in the physical controllers. A POSA would have been able to leverage Pedrotti's existing system and hardware to implement binaural audio, which requires input of positional and orientation information of the user. Pedrotti also discloses and teaches providing audio to the user, e.g., audio warnings. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedrotti does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**8. U.S. Patent No. 9,041,622 ("McCulloch")**

The chart attached as Exhibit G-08 provides examples of where McCulloch discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent McCulloch does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify McCulloch with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to



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determine that any limitation of the Asserted Claims of the ’509 Patent are not disclosed and/or rendered obvious by McCulloch and/or McCulloch and such references, the Asserted Claims of the ’509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, enabling tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within the safety boundaries as discussed in McCulloch. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, McCulloch discloses and teaches that “[u]ser input data is received from a real controller device requesting an action to be performed by the virtual object.” Providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. McCulloch discloses and teaches creating a map



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of the environment, and so a POSA would be motivated to incorporate additional features to notify the user regarding the location with respect to this mapped environment. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that McCulloch does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**9. Sony Playstation VR System ("Sony PSVR System")**

The chart attached as Exhibit G-09 provides examples of where Sony PSVR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Sony PSVR System does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Sony PSVR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Sony PSVR System and/or Sony PSVR System and such



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references, the Asserted Claims of the ’509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Sony PSVR System already uses head tracking and controller tracking, through positional tracking with LEDs, so a POSA would have been able to leverage Sony PSVR System’s existing hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Sony PSVR System also includes a play area definition feature using external sensors, so a POSA would have been motivated to increase the flexibility of defining the play area by using user input to define the play area. Additionally, the known solutions disclosed in many prior art references were often



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discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sony PSVR System does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**10. HTC Vive System ("HTC Vive System")**

The chart attached as Exhibit G-10 provides examples of where HTC Vive System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent HTC Vive System does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify HTC Vive System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 6, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by HTC Vive System and/or HTC Vive System and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve



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predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Indeed, HTC Vive System uses a camera-enabled Chaperone guidance system, which tracks the position and orientation of the user. HTC Vive System also uses 3D audio processing, but not through a built-in solution. A POSA would have been able to leverage the existing hardware and processing of HTC Vive System to implement binaural audio, which requires input of positional and orientation information of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that HTC Vive



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System does not disclose one or more limitations of the Asserted Claims of the ’509 Patent.

### 11. Oculus Rift System (“Oculus Rift System”)

The chart attached as Exhibit G-11 provides examples of where Oculus Rift System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Oculus Rift System does not anticipate and/or render obvious the Asserted Claims of the ’509 Patent on its own, it would have been obvious to combine or modify Oculus Rift System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’509 Patent are not disclosed and/or rendered obvious by Oculus Rift System and/or Oculus Rift System and such references, the Asserted Claims of the ’509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation



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sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Oculus Rift System already uses six degree of freedom rotational and positional tracking, so a POSA would have been able to leverage the existing hardware and processing of Oculus Rift System to implement safety boundaries and tracking the user with respect to those boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Moreover, design incentives and other market forces would have prompted those endeavors. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Oculus Rift System does not disclose one or more limitations of the Asserted Claims of the ’509 Patent

### 12. Microsoft HoloLens System (“Microsoft HoloLens System”)

The chart attached as Exhibit G-12 provides examples of where Microsoft HoloLens System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition,



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to the extent Microsoft HoloLens System does not anticipate and/or render obvious the Asserted Claims of the ’509 Patent on its own, it would have been obvious to combine or modify Microsoft HoloLens System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’509 Patent are not disclosed and/or rendered obvious by Microsoft HoloLens System and/or Microsoft HoloLens System and such references, the Asserted Claims of the ’509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room;



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and other scanning and sensing technologies. Indeed, Microsoft's HoloLens System already uses position tracking, so a POSA would have been able to leverage the existing hardware and processing of Microsfot's HoloLens System to implement safety boundaries and tracking the user with respect to those boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Microsoft HoloLens System does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

### 13. 3D Audio Interface for Rich Mobile Web Experiences ("Wu")

The chart attached as Exhibit G-13 provides examples of where Wu discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Wu does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Wu with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation



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of the Asserted Claims of the ’509 Patent are not disclosed and/or rendered obvious by Wu and/or Wu and such references, the Asserted Claims of the ’509 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience, which is typically implemented using a head-mounted device or a wearable device that provides an image to the user. Specifically, Wu explains that applications of its described 3D audio interface is not limited to simply audio, but rather enhances mobile web experiences including visual experiences, e.g., YouTube video stream or users playing a virtual board game. A more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Wu discloses and teaches that “calculat[ing] the position of the user” as well as allowing the user to control location in audio space. Additionally, the known solutions disclosed in many prior art



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references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to combine the mobile-implemented experience with a head-mounted device or wearable device, enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Wu does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

**14. 3-D Sound for Virtual Reality and Multimedia ("Begault 2000")**

The chart attached as Exhibit G-14 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '509 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault 2000 does not anticipate and/or render obvious the Asserted Claims of the '509 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-5, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '509 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the '509 Patent are nevertheless unpatentable as obvious because they contain nothing that



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constitutes patentable innovation—no Asserted Claim of the '509 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience, which is typically implemented using a head-mounted device or a wearable device that provides an image to the user. A more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Begault 2000 discloses and teaches that "[s]ensors, hardware such as magnetic or mechanical position trackers, six- degrees-of-freedom trackballs, speech analyzers, and data gloves" for tracking the position of the user for use in producing spatial audio. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well known and well-understood techniques together, in a predictable manner, to yield nothing more than



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predictable results. A POSA would have known and been motivated to enable tracking between a wearable device and a handheld device, as well as tracking the user's location through either a wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the '509 Patent.

### H. The '316 Patent

As further explained below and in Exhibits H-01 to H-13, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the '316 Patent under 35 U.S.C. § 102 and/or § 103:

- Osman, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, and/or 7, and/or Section IV.H, for example and without limitation (i) Osman and Pedrotti and Flaks 968, including in view of Second Life, (ii) Osman and Ashforth and Wan, including in view of Second Life, (iii) Osman and Sawyer, including in view of Second Life, (iv) Osman and Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Sawyer, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, and/or Section IV.H, for example and without limitation (i) Sawyer and Wan and Gorzel, including in view of Second Life, (ii) Sawyer and Wan and Lovitt and Flaks 968, including in view of Second Life, (iii) Sawyer and Wan and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iv) Sawyer and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Lovitt, alone or in view of one or more of the prior art references and products identified in Sections IV.J.3-5, and/or 7, and/or Section IV.H, for example and without limitation (i) Lovitt and Pedrotti and Flaks 968, including in view of Second Life, (ii) Lovitt and Ashforth and Wan, including in view of Second Life, (iii) Lovitt and Sawyer, including in view of Second Life, (iv) Lovitt and Pedrotti and Jang, including in view of Begault



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2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

- Katz 031, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-7, and/or Section IV.H, for example and without limitation (i) Katz 031 and Flaks 068 and Pedrotti, including in view of Second Life, (ii) Katz 031 and Wan and Gorzel and Sawyer, including in view of Second Life, (iii) Katz 031 and Lovitt and Ashforth, including in view of Second Life, (iv) Katz 031 and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Ashforth, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, and/or 6-7, and/or Section IV.H, for example and without limitation (i) Ashforth and Jang, including in view of Begault 2000 and/or Second Life, (ii) Ashforth and Wan and and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iii) Ashforth and Wan and Gorzel, including in view of Second Life,, (iv) Ashforth and Lovitt and Flaks 968, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Balachandreswaran, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, and/or 3-7, and/or Section IV.H, for example and without limitation (i) Balachandreswaran and Flaks 068 and Pedrotti, including in view of Second Life, (ii) Balachandreswaran and Wan and Gorzel and Sawyer, including in view of Second Life, (iii) Balachandreswaran and Lovitt and Ashforth, including in view of Second Life, (iv) Balachandreswaran and Jang and Flaks 968, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Pedrotti, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-4, 6, and/or 12, and/or Section IV.H, for example and without limitation (i) Pedrotti and Jang, including in view of Begault 2000 and/or Second Life, (ii) Pedrotti and Jang and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iii) Pedrotti and Osman and Wan, including in view of Second Life, (iv) Pedrotti and McCulloch, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- McCulloch, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, 7, and/or 12, and/or Section IV.H, for example and without limitation (i) McCulloch and Pedrotti, including in view of Second Life, (ii) McCulloch and Ashforth, including in view of Second Life, (iii) McCulloch and Gum, including in view of Second Life, (iv) McCulloch and Sawyer, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.



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- Sony PSVR System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, 7, and/or 12, and/or Section IV.H, for example and without limitation (i) Sony PSVR System and Pedrotti and Flaks 968, including in view of Second Life, (ii) Sony PSVR System and Ashforth and Gorzel, including in view of Second Life, (iii) Sony PSVR System and McCulloch, including in view of Lovitt, (iv) Sony PSVR System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- HTC Vive System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 6-7, and/or 12, and/or Section IV.H, for example and without limitation (i) HTC Vive System and Flaks 968, including in view of Second Life, (ii) HTC Vive System and Wan and Gorzel, including in view of Second Life, (iii) HTC Vive System and Begault 2000, including in view of Second Life, (iv) HTC Vive System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Oculus Rift System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 3-5, 7, and/or 12, and/or Section IV.H, for example and without limitation (i) Oculus Rift System and Pedrotti and Flaks 968, including in view of Second Life, (ii) Oculus Rift System and Ashforth and Flaks 968, including in view of Second Life, (iii) Oculus Rift System and McCulloch, including in view of Lovitt, (iv) Oculus Rift System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Microsoft HoloLens System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 5, 7, and/or 12, and/or Section IV.H, for example and without limitation (i) Microsoft HoloLens System and Flaks 968, including in view of Second Life, (ii) Microsoft HoloLens System and Wan and Gorzel, including in view of Second Life, (iii) Microsoft HoloLens System and Begault 2000, including in view of Second Life, (iv) Microsoft HoloLens System and Jang, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Wu, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-5, 7, and/or 12, and/or Section IV.H, for example and without limitation (i) Wu and Wan and Jang, including in view of Begault 2000 and/or Second Life, (ii) Wu and McCulloch, including in view of Begault 2000 and/or Second Life, (iii) Wu and Wan and Cohen 1993 I, including in view of Begault 2000 and/or Second Life, (iv) Wu and Pedrotti, including in view of Begault 2000 and/or Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.
- Begault 2000, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1-5, 7, and/or 12, and/or and/or Section IV.H, for example



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and without limitation (i) Begault 2000 and Wan and Jang, including in view of Second Life, (ii) Begault 2000 and McCulloch and Pedrotti, including in view of Second Life, (iii) Begault 2000 and Lovitt and Sawyer, including in view of Second Life, (iv) Begault 2000 and Ashforth and Cohen 1993 I, including in view of Second Life, which a POSA would have known and been motivated to combine for at least the reasons explained in the following subsections.

### 1. U.S. Patent No. 9,037,468 ("Osman")

The chart attached as Exhibit H-01 provides examples of where Osman discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Osman does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it would have been obvious to combine or modify Osman with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 7, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Osman and/or Osman and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or



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obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create boundaries and track the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Osman already discloses and teaches position tracking, so a POSA would have been able to leverage Osman's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Additionally, the solutions disclosed in many prior art were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Osman does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

**2. U.S. Patent Pub. No. 2016/0124502 ("Sawyer")**

The chart attached as Exhibit H-02 provides examples of where Sawyer discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus



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anticipates those claims and/or renders those claims obvious. In addition, to the extent Sawyer does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it would have been obvious to combine or modify Sawyer with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, and/or 6, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Sawyer and/or Sawyer and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within the safety boundaries as discussed in Sawyer. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers,



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torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Sawyer discloses and teaches tracking an "object," which includes the HMD or controller; a POSA would have used the existing tracking system in combination with implementing binaural audio, which requires deriving the user's head position, location, and orientation. Sawyer also discloses and teaches examples of virtual game elements in the Sawyer environment from which sound emanates, which would be the candidates for binaural audio. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sawyer does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

**3. U.S. Patent Pub. No. 2015/0119130 ("Lovitt")**

The chart attached as Exhibit H-03 provides examples of where Lovitt discloses, either



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expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Lovitt does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify Lovitt with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, and/or 7, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by Lovitt and/or Lovitt and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and



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infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Lovitt already discloses and teaches capturing depth information (e.g., structure light depth camera) and positioning systems offering six degrees of freedom, so a POSA would have been able to leverage Lovitt's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Lovitt, in the context of generating binaural audio, discloses a "world space," which a POSA would have known to use as a shared, universal coordinate system on which to map safety boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Lovitt does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

#### 4. U.S. Patent No. 10,095,031 ("Katz 031")

The chart attached as Exhibit H-04 provides examples of where Katz 031 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Katz 031 does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it



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would have been obvious to combine or modify Katz 031 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-7, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Katz 031 and/or Katz 031 and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within safety boundaries for the user that define the play area. These safety boundaries alleviate the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art further teaches techniques for this, such as use of positioning systems (e.g., GPS, Wi-Fi



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location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Katz 031 discloses and teaches a VR headset with at least two cameras, multiple position sensors, and an inertial measurement unit, which provides positional and directional information regarding the VR headset; a POSA would have leveraged all of these existing features and hardware to implement safety boundaries for the user and tracking the user's location. Katz 031 further discloses and teaches the VR headset communicating with a console where additional processing can take place, such as additional processing that may be necessary for running an audio engine, visual engine for displaying safety boundaries, or tracking among the VR headset, the VR input interface (such as in the form of a handheld device), and the VR console itself. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Likewise, a POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to



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those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Katz 031 does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

**5. U.K. Patent Appl. No. GB2524269A ("Ashforth")**

The chart attached as Exhibit H-05 provides examples of where Ashforth discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ashforth does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it would have been obvious to combine or modify Ashforth with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, and/or 6-7, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Ashforth and/or Ashforth and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that



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the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within safety boundaries as discussed in Ashforth. The prior art further teaches techniques for this, such as the use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Ashforth discloses and teaches communication between the Move controller and the HMD with the games console, where additional processing can take place, such as for tracking among the Move controller, the HMD, and the games console itself. Ashforth further discloses and teaches using the HMD to reproduce audio signals generated by the games console, such that a POSA would have been motivated to modify the generated audio signals to reflect binaural audio, since audio signal generation already occurs at the games console and the Ashforth's system is able to detect the user's physical position. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than



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predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Furthermore, a POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ashforth does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

**6. U.S. Patent Pub. No. 2016/0292924 ("Balachandreswaran")**

The chart attached as Exhibit H-06 provides examples of where Balachandreswaran discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Balachandreswaran does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it would have been obvious to combine or modify Balachandreswaran with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, and/or 3-7, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Balachandreswaran and/or Balachandreswaran and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for



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example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art further teaches techniques for this, such as the use of positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Balachandreswaran already discloses and teaches position and orientation tracking using time-of-flight information and laser beams, so a POSA would have been able to leverage Balachandreswaran's existing system and hardware when implementing safety boundaries and tracking the user with respect to those boundaries. A POSA would have also used the tracking information to implement binaural audio in Balachandreswaran's system, since Balachandreswaran already discloses an audio module with speakers and microphone for audio input and output. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.



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To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable communication and tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Furthermore, a POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Balachandrewswaran does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

**7. U.S. Patent No. 9,851,786 ("Pedrotti")**

The chart attached as Exhibit H-07 provides examples of where Pedrotti discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Pedrotti does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it would have been obvious to combine or modify Pedrotti with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-4, 6, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Pedrotti and/or Pedrotti and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable



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innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Indeed, Pedrotti discloses and teaches tracking the position and orientation of the HMD as well as the position and orientation of one or more trackers in the physical controllers. A POSA would have been able to leverage Pedrotti’s existing system and hardware to implement binaural audio, which requires input of positional and orientation information of the user. Pedrotti also discloses and teaches providing audio to the user, e.g., audio warnings. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Design



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incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Pedrotti does not disclose one or more limitations of the Asserted Claims of the ’316 Patent.

**8. U.S. Patent No. 9,041,622 (“McCulloch”)**

The chart attached as Exhibit H-08 provides examples of where McCulloch discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent McCulloch does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify McCulloch with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, 7 and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by McCulloch and/or McCulloch and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, enabling tracking between the wearable device and a handheld device to reduce externalities, and similarly, to track both devices within the safety boundaries as discussed in



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McCulloch. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, McCulloch discloses and teaches that "[u]ser input data is received from a real controller device requesting an action to be performed by the virtual object." Providing the user with a more immersive extended reality experience is also achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. McCulloch discloses and teaches creating a map of the environment, and so a POSA would be motivated to incorporate additional features to notify the user regarding the location with respect to this mapped environment. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with



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additional positions on obviousness in response to any allegation by Plaintiff that McCulloch does not disclose one or more limitations of the Asserted Claims of the ’316 Patent.

**9. Sony Playstation VR System (“Sony PSVR System”)**

The chart attached as Exhibit H-09 provides examples of where Sony PSVR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Sony PSVR System does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify Sony PSVR System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, 7, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by Sony PSVR System and/or Sony PSVR System and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through



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positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Sony PSVR System already uses head tracking and controller tracking, through positional tracking with LEDs, so a POSA would have been able to leverage Sony PSVR System's existing hardware when implementing safety boundaries and tracking the user with respect to those boundaries. Sony PSVR System also includes a play area definition feature using external sensors, so a POSA would have been motivated to increase the flexibility of defining the play area by using user input to define the play area. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sony PSVR System does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

**10. HTC Vive System ("HTC Vive System")**

The chart attached as Exhibit H-10 provides examples of where HTC Vive System



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discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent HTC Vive System does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify HTC Vive System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 6-7, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by HTC Vive System and/or HTC Vive System and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques for this, such as using certain head-related transfer functions convolved with a source sound to generate binaural audio. Indeed, HTC Vive System uses a camera-enabled Chaperone guidance system, which tracks the position and orientation of the user. HTC Vive System also uses 3D audio processing, but not through a built-in solution. A POSA would have been able to leverage the existing hardware and processing of HTC Vive System to implement



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binaural audio, which requires input of positional and orientation information of the user. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that HTC Vive System does not disclose one or more limitations of the Asserted Claims of the ’316 Patent.

### 11. Oculus Rift System (“Oculus Rift System”)

The chart attached as Exhibit H-11 provides examples of where M Oculus Rift System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Oculus Rift System does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify Oculus Rift System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 3-5, 7, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by Oculus Rift System and/or Oculus Rift System and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the



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’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user’s need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Oculus Rift System already uses six degree of freedom rotational and positional tracking, so a POSA would have been able to leverage the existing hardware and processing of Oculus Rift System to implement safety boundaries and tracking the user with respect to those boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than



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predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Moreover, design incentives and other market forces would have prompted those endeavors. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Oculus Rift System does not disclose one or more limitations of the Asserted Claims of the ’316 Patent

**12. Microsoft HoloLens System (“Microsoft HoloLens System”)**

The chart attached as Exhibit H-12 provides examples of where Microsoft HoloLens System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Microsoft HoloLens System does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify Microsoft HoloLens System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 5, 7, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by Microsoft HoloLens System and/or Microsoft HoloLens System and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for



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example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing safety boundaries for the user that define the play area, which alleviates the user's need to worry about or be distracted by the physical surroundings or obstacles while being immersed in the extended reality experience. The prior art teaches techniques to create the boundaries and tracking the user within those boundaries, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Microsoft HoloLens System already uses position tracking, so a POSA would have been able to leverage the existing hardware and processing of Microsoft HoloLens System to implement safety boundaries and tracking the user with respect to those boundaries. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide safety boundaries for the user, and relatedly, tracking the user in relation to those boundaries based on a variety of techniques. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Microsoft HoloLens System does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

### 13. 3D Audio Interface for Rich Mobile Web Experiences ("Wu")

The chart attached as Exhibit H-13 provides examples of where Wu discloses, either expressly or inherently, each limitation of the Asserted Claims of the '316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Wu does not anticipate and/or render obvious the Asserted Claims of the '316 Patent on its own, it would have been obvious to combine or modify Wu with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-5, 7, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '316 Patent are not disclosed and/or rendered obvious by Wu and/or Wu and such references, the Asserted Claims of the '316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience, which is typically implemented using a head-mounted device or a wearable device that provides an image to the user. Specifically, Wu explains that applications of its described 3D audio interface is not limited



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to simply audio, but rather enhances mobile web experiences including visual experiences, e.g., YouTube video stream or users playing a virtual board game. A more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce externalities. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Wu discloses and teaches that "calculat[ing] the position of the user" as well as allowing the user to control location in audio space. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald and Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to combine the mobile-implemented experience with a head-mounted device or wearable device, enable tracking between the wearable device and a handheld device, as well as tracking the user's location through either the wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.



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Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Wu does not disclose one or more limitations of the Asserted Claims of the ’316 Patent.

**14. 3-D Sound for Virtual Reality and Multimedia (“Begault 2000”)**

The chart attached as Exhibit H-14 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’316 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault 2000 does not anticipate and/or render obvious the Asserted Claims of the ’316 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1-5, 7, and/or 12, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’316 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the ’316 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’316 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the above-references, for example, seek to provide the user with a more immersive extended reality experience, which is typically implemented using a head-mounted device or a wearable device that provides an image to the user. A more immersive extended reality experience is also achievable by, for example, enabling communication and tracking between the wearable device and a handheld device to reduce



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externalities. The prior art teaches the use well-known techniques, such as through positioning systems (e.g., GPS, Wi-Fi location, or radio frequency); positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the wearable device and/or handheld device; depth cameras and image tracking (e.g., LEDs and infrared lights); map making; or constellation sensors and markers placed throughout the room; and other scanning and sensing technologies. Indeed, Begault 2000 discloses and teaches that "[s]ensors, hardware such as magnetic or mechanical position trackers, six- degrees-of-freedom trackballs, speech analyzers, and data gloves" for tracking the position of the user for use in producing spatial audio. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Jerald.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to enable tracking between a wearable device and a handheld device, as well as tracking the user's location through either a wearable device or the handheld device. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the '316 Patent.

## I. The '836 Patent

As further explained below and in Exhibits I-01 to I-14, the following prior art references, and any products, devices, or methods known or used in the prior art that embody the subject



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matter disclosed in those prior art references and products, anticipate and/or render obvious the Asserted Claims of the '836 Patent under 35 U.S.C. § 102 and/or § 103:

- Osman, alone or in view of one or more of the prior art references and products identified in Section IV.J.2 and/or IV.J.6, and/or Section IV.I, for example and without limitation (i) Osman and the Sony PSVR System, including in view of Romblom, Finnegan and/or Algazi 2001, (ii) Osman and Ermilov, including in view of Romblom, Finnegan and/or Algazi 2001, (iii) Osman and Flaks 968, and (iv) Osman and Kim 417, including in view of Romblom, Finnegan and/or Algazi 2001.
- Shivappa 843, alone or in view of one or more of the prior art references and products identified in Section IV.J.2, 6 and/or 9, and/or Section IV.I, for example and without limitation (i) Shivappa 843 in view of Romblom and/or Algazi 2001, (ii) Shivappa 843 and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Shivappa 843 and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Shivappa 843 and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Shivappa 063, alone or in view of one or more of the prior art references and products identified in Section IV.J.2, 6 and/or 9, and/or Section IV.I, for example and without limitation (i) Shivappa 063 in view of Romblom and/or Algazi 2001, (ii) Shivappa 063 and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Shivappa 063 and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Shivappa 063 and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Norris 090, alone or in view of one or more of the prior art references and products identified in Section IV.J.2, 6, and/or 9, and/or Section IV.I, , for example and without limitation (i) Norris 090 in view of Algazi 2001 and/or Romblom, (ii) Norris 090 and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Norris 090 and Flaks 968, including in view of Romblom and/or Algazi 2001, and (iv) Shivappa 063 and the HTC Vive System, including in view of Romblom and/or Algazi 2001.
- Ermilov, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6 and/or 9, and/or Section IV.I, for example and without limitation (i) Ermilov and the Oculus Rift System, including in view of Romblom and/or Algazi 2001, (ii) Ermilov and the HTC Vive System 2000, including in view of Romblom and/or Algazi 2001, (iii) Ermilov and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Ermilov and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Wright, alone or in view of one or more of the prior art references and products identified in Sections IV.J.1, 2, 6, and/or 8, and/or Section IV.I, , for example and without limitation (i) Wright and the HTC Vive System, including in view of Romblom and/or Algazi 2001, (ii) Wright and Begault 2000, including in view of Finnegan, Romblom and/or Algazi 2001, (iii) Wright and Kim 417, including in



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view of Romblom and/or Algazi 2001, and (iv) Wright and Flaks 968, including in view of Romblom and/or Algazi 2001.

- Laitinen, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2 6, 8 and/or 9, and/or Section IV.I, for example and without limitation, (i) Laitinen and Norris 090 in view of Romblom and/or Algazi 2001, (ii) Laitinen and Osman in view of Romblom and/or Algazi 2001, and (iii) Laitinen and HTC Vive system in view of Romblom and/or Algazi 2001.
- Kim 417, alone or in view of one or more of the prior art references and products identified in Section IV.J.2, 6, 8, and/or 9, and/or Section IV.I, for example and without limitation, Kim 417 and Norris 090 in view of Romblom and/or Algazi 2001, Kim 417 and Osman in view of Sony PSVR system, Romblom and/or Algazi 2001, (iii) Kim 417 and HTC Vive in view of Romblom and/or Algazi 2001, and Kim 417 and Shivappa 843 in view of Romblom and/or Algazi 2001
- Lovitt, alone or in view of one or more of the prior art references and products identified in Section IV.J.2, 6, 8, and 9, and/or Section IV.I, for example and without limitation, (i) Lovitt and Norris 090 in view of Romblom and/or Algazi 2001, (ii) Lovitt and Osman in view of Romblom and/or Algazi 2001, and (iii) Lovitt and HTC Vive system in view of Romblom and/or Algazi 2001.
- Etter 631, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6 and/or 9, and/or Section IV.I, for example and without limitation (i) Etter 631in view of Romblom and/or Algazi 2001, (ii) Etter 631 and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Etter 631and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Etter 631 and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Begault 2000, alone or in view of one or more of the prior art references and products identified in Section IV.J.2, 6 and/or 9, and/or Section IV.I, for example and without limitation (i) Begault 2000 and HTC Vivie, including in view of Romblom and/or Algazi 2001, (ii) Begault 2000 and Norris 090, including in view of Romblom and/or Algazi 2001, (iii) Begault 2000 and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Begault 2000 and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Algazi 2011, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6, and/or 9, and/or Section IV.I, for example and without limitation (i) Algazi 2011 and HTC Vive system, including in view of Romblom and/or Algazi 2001, (ii) Algazi 2011 and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Algazi 2011 and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Algazi 2011 and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Sony PSVR System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6, 9 and/or 12, and/or Section IV.I, for example and without limitation (i) Sony PSVR System and Osman in view of Romblom and/or Algazi 2001, (ii) Sony PSVR System and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Sony PSVR System and Norris 090,



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including in view of Romblom and/or Algazi 2001, and (iv) Sony PSVR System and Flaks 968, including in view of Romblom and/or Algazi 2001.

- HTC Vive System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6, 9 and/or 12, and/or Section IV.I, for example and without limitation (i) HTC Vive System and Norris 090 in view of Romblom and/or Algazi 2001, (ii) HTC Vive System and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) HTC Vive System and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) HTC Vive System and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Oculus Rift System, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6, 9 and/or 12, and/or Section IV.I, for example and without limitation (i) Oculus Rift System in view of Finnegan, Romblom and/or Algazi 2001, (ii) Oculus Rift System and Begault 2000, including in view of Romblom and/or Algazi 2001, (iii) Oculus Rift System and Kim 417, including in view of Romblom and/or Algazi 2001, and (iv) Oculus Rift System and Flaks 968, including in view of Romblom and/or Algazi 2001.
- Finnegan, alone or in view of one or more of the prior art references and products identified in Sections IV.J.2, 6, 9, and/or 12, and/or Section IV.I, for example and without limitation (i) Finnegan and Oculus Rift System, including in view of AltSpaceVR and Audio Spatializer SDK (Unity 5.3), (ii) Finnegan and HTC Vive System, (iii) Finnegan and Osman, including in view of Sony PSVR system and Algazi 2001, (iv) Finnegan and Shivappa 063, including in view of Algazi 2001.

#### 1. U.S. Patent No. 9,037,468 ("Osman")

The chart attached as Exhibit I-01 provides examples of where Osman discloses, either expressly or inherently, each limitation of the Asserted Claims of the '836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Osman does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Osman with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Osman and/or Osman and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable



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innovation—no Asserted Claim of the ’836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, the prior art identified in Sections IV.J.2, 6 and 9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing wearable devices with a display where images are rendered in relation to a sound source using head-related transfer functions or other processing for binaural audio. The prior art teaches techniques to process and playback binaural audio, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Indeed, Osman already discloses and teaches augmented-reality environment with realistic delivery of sound based on the orientation of a portable device, so a POSA would have been able to leverage Osman’s existing system and hardware when implementing a wearable device with a display where images are rendered in relation to a sound source.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to have a wearable device with a display where images are rendered in relation to a sound source to increase the interaction



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between the user and system to provide a more realistic user experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Osman does not disclose one or more limitations of the Asserted Claims of the '836 Patent.

**2. U.S. Patent No. 10,979,843 ("Shivappa 843")**

The chart attached as Exhibit I-02 provides examples of where Shivappa 843 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Shivappa 843 does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Shivappa 843 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Shivappa 843 and/or Shivappa 843 and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Also, the prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing 3D audio such that the user experiences the sound as



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emanating from a point in three-dimensional space that is related to a corresponding image rendered image. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well-known techniques of generating binaural audio so that images are rendered in relation to a sound to provide a more realistic user experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Shivappa 843 does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

### 3. U.S. Patent No. 10,089,063 (“Shivappa 063”)

The chart attached as Exhibit I-03 provides examples of where Shivappa 063 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Shivappa 063 does not anticipate and/or render obvious the Asserted Claims of the ’836 Patent on its own, it would have been obvious to combine or modify Shivappa 063 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 6, and/or 9, or



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similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Shivappa 063 and/or Shivappa 063 and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Also, the prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing 3D audio such that the user experiences the sound as emanating from a point in three-dimensional space that is related to a corresponding image rendered image. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive



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audio experience based on the well-known techniques of generating binaural audio so that images are rendered in relation to a sound to provide a more realistic user experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Shivappa 063 does not disclose one or more limitations of the Asserted Claims of the '836 Patent.

**4. U.S. Patent No. 9,226,090 ("Norris 090")**

The chart attached as Exhibit I-04 provides examples of where Norris 090 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Norris 090 does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Norris 090 with concepts and features disclosed in other prior art references and products identified in Sections IV.J. 2, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Norris 090 and/or Norris 090 and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Also, the prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive extended reality experience. This is



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achievable by, for example, providing 3D audio such that the user experiences the sound as emanating from a point in three-dimensional space that is related to a corresponding image rendered image. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well-known techniques of generating binaural audio so that images are rendered in relation to a sound to provide a more realistic user experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Norris 090 does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

**5. U.S. Patent Pub. No. 2016/0124707 (“Ermilov”)**

The chart attached as Exhibit I-05 provides examples of where Ermilov discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Ermilov does not anticipate and/or render obvious the Asserted Claims of the ’836 Patent on its own, it would have been obvious to combine or modify Ermilov with concepts and features disclosed in



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other prior art references and products identified in Sections IV.J.2, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Ermilov and/or Ermilov and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are directed to systems for video-capable portable devices and include discussions of virtual or augmented reality systems. Also, the prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive video experience, including through virtual or augmented reality. This is achievable by, for example, providing 3D audio such that the user experiences the sound as emanating from a point in three-dimensional space that is related to a corresponding image rendered image. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such Begault 2000. Similarly, the other prior art as identified in Sections IV.J.2 all relate to wearable devices with a display that provide the user with a more immersive extended (i.e. virtual or augmented) reality experience, by, for example, providing virtual objections at various localization points.



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To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio and video experience based on the well-known video systems. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Ermilov does not disclose one or more limitations of the Asserted Claims of the '836 Patent.

**6. U.S. Patent No. 9,530,426 ("Wright")**

The chart attached as Exhibit I-06 provides examples of where Wright discloses, either expressly or inherently, each limitation of the Asserted Claims of the '836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Wright does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Wright with concepts and features disclosed in other prior art references and products identified in Sections IV.J.1, 2, 6, 8, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Wright and/or Wright and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.



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The reasons or motivations to combine the prior art discussed above would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Also, the prior art identified in Sections IV.J.1, IV.J.2, IV.J.6, IV.J.8, and IV.J.9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing 3D audio such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to process and playback binaural audio, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner, to yield nothing more than predictable results. A POSA would have known and been motivated to provide a more immersive audio experience based on the well-known techniques, such as using head-related transfer functions convolved with a source sound to generate binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Wright does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

**7. U.S. Patent No. 8,587,631 (“Etter 631”)**

The chart attached as Exhibit I-07 provides examples of where Etter 631 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus



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anticipates those claims and/or renders those claims obvious. In addition, to the extent Etter 631 does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Etter with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Etter 631 and/or Etter 631 and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivations to combine the prior art discussed above would include, for example, that the references are directed to systems for video-capable portable devices. Also, the prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive video experience. This is achievable by, for example, providing 3D audio such that the user experiences the sound as emanating from a point in three-dimensional space that is related to a corresponding image rendered image. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000. Similarly, the other prior art as identified in Sections IV.J.2 all related to wearable devices with a display that provide



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the user with a more immersive extended (i.e. virtual or augmented) reality experience, by, for example, providing virtual objections at various localization points.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner to provide a more immersive audio and video experience based on the well-known video systems. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Etter 631 does not disclose one or more limitations of the Asserted Claims of the '836 Patent.

**8. 3-D Sound for Virtual Reality and Multimedia ("Begault 2000")**

The chart attached as Exhibit I-08 provides examples of where Begault 2000 discloses, either expressly or inherently, each limitation of the Asserted Claims of the '836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Begault 2000 does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Begault 2000 with concepts and features disclosed in other prior art references and products identified in Section IV.J.2, 6, and/or 9, or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Begault 2000 and/or Begault 2000 and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.



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The reasons or motivation to combine this prior art would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner to provide a more immersive audio experience based on the well-known techniques of generating binaural audio so that images are rendered in relation to a sound to provide a more realistic user experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Begault 2000 does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

### 9. Headphone-Based Spatial Sound (“Algazi 2011”)

The chart attached as Exhibit I-09 provides examples of where Algazi 2011 discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Algazi 2011 does not anticipate and/or render obvious the Asserted Claims of the ’836 Patent on its own,



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it would have been obvious to combine or modify Algazi 2011 with concepts and features disclosed in other prior art references and products identified in Sections IV.J.2, 6, and/or 9 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Algazi 2011 and/or Algazi 2011 and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivation to combine this prior art would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, prior art identified in Section IV.J.9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and



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well-understood techniques together, in a predictable manner to provide a more immersive audio experience based on the well-known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Algazi 2011 does not disclose one or more limitations of the Asserted Claims of the '836 Patent.

**10. Sony PlayStation VR System ("Sony PSVR System")**

The chart attached as Exhibit I-10 provides examples of where Sony PSVR System discloses, either expressly or inherently, each limitation of the Asserted Claims of the '836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Sony PSVR System does not anticipate and/or render obvious the Asserted Claims of the '836 Patent on its own, it would have been obvious to combine or modify Sony PSVR System with concepts and features disclosed in other prior art references and products identified in Section IV.J.6, 9, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by Sony PSVR System and/or Sony PSVR System and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivation to combine this prior art would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, prior art identified in Sections IV.J.6 and 9, for example, seek to provide the user with a more immersive extended reality experience. This is



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achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner to provide a more immersive audio experience based on the well-known techniques of generating binaural audio so that images are rendered in relation to a sound to provide a more realistic user experience. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Sony PSVR System does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

### 11. HTC Vive System (“HTC Vive System”)

The chart attached as Exhibit I-11 provides examples of where HTC Vive System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent HTC Vive System does not anticipate and/or render obvious the Asserted Claims of the ’836 Patent on its own, it would have been obvious to combine or modify HTC Vive System with concepts and features disclosed in other prior art references and products identified in Sections



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IV.J.6, 9, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the '836 Patent are not disclosed and/or rendered obvious by HTC Vive System and/or HTC Vive System and such references, the Asserted Claims of the '836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the '836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivation to combine this prior art would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, prior art identified in Sections IV.J.6 and 9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner to provide a more immersive audio experience based on the well-known techniques of generating binaural audio. Design incentives



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and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that HTC Vive does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

**12. Oculus Rift System (“Oculus Rift System”)**

The chart attached as Exhibit I-12 provides examples of where Oculus Rift System discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Oculus Rift System does not anticipate and/or render obvious the Asserted Claims of the ’836 Patent on its own, it would have been obvious to combine or modify Oculus Rift System with concepts and features disclosed in other prior art references and products identified in Sections IV.J.6, 9, and/or 12 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’836 Patent are not disclosed and/or rendered obvious by Oculus Rift System and/or Oculus Rift System and such references, the Asserted Claims of the ’836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivation to combine this prior art would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, prior art identified in Sections IV.J.6 and 9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space.



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The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner to provide a more immersive audio experience based on the well-known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with additional positions on obviousness in response to any allegation by Plaintiff that Oculus Rift System does not disclose one or more limitations of the Asserted Claims of the ’836 Patent.

### 13. Compensating for Distance Compression in Virtual Audiovisual Virtual Environments Using Incongruence (“Finnegan”)

The chart attached as Exhibit I-13 provides examples of where Finnegan discloses, either expressly or inherently, each limitation of the Asserted Claims of the ’836 Patent and thus anticipates those claims and/or renders those claims obvious. In addition, to the extent Finnegan does not anticipate and/or render obvious the Asserted Claims of the ’836 Patent on its own, it would have been obvious to combine or modify it with concepts and features disclosed in other prior art references and products identified in Section IV.J. 2, 6 and/or 9 or similar references and products. Indeed, as noted above, even if a finder of fact were to determine that any limitation of the Asserted Claims of the ’836 Patent are not disclosed and/or rendered obvious by Finnegan



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and/or Finnnegan and such references, the Asserted Claims of the ’836 Patent are nevertheless unpatentable as obvious because they contain nothing that constitutes patentable innovation—no Asserted Claim of the ’836 Patent goes beyond combining familiar elements according to known methods to achieve predictable results, or does more than choose between clear alternatives known to a POSA.

The reasons or motivation to combine this prior art would include, for example, that the references are all directed to extended reality systems, which include both virtual reality and augmented reality systems. Additionally, prior art identified in Section IV.J.2, 6, and 9, for example, seek to provide the user with a more immersive extended reality experience. This is achievable by, for example, providing binaural audio through the speakers of the wearable device such that the user experiences the sound as emanating from a point in three-dimensional space. The prior art teaches techniques to process and playback binaural audio such that the sound source and image rendering are in accord, including the use of head-related transfer functions, digital signal processors, and positional or orientation sensors (e.g., gyroscopic sensors, magnetometers, accelerometers, torque sensors) for the device. Additionally, the known solutions disclosed in many prior art references were often discussed in textbooks and comprehensive guides, such as Begault 2000.

To be clear, to a POSA, the features recited in the Asserted Claims would have been obvious to try and predictable, and they would have been the result of combining well-known and well-understood techniques together, in a predictable manner to provide a more immersive audio experience based on the well-known techniques of generating binaural audio. Design incentives and market forces would have prompted such endeavors and features.

Defendants reserve the right to supplement or amend these invalidity contentions with



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additional positions on obviousness in response to any allegation by Plaintiff that Finnegan does not disclose one or more limitations of the Asserted Claims of the '836 Patent.

### J. Additional References Relevant To Obviousness Of The Asserted Claims

As discussed above, Defendants contend that the Asserted Claims are obvious, including because they merely arrange old elements that were well-known and obvious to try to a POSA, with each performing the same function it had been previously known to perform and yielding no more than expect results. The additional, exemplary references and products identified in the following subsections demonstrate as much, including because they show that features the Asserted Claims recite were well-known and well within the level of ordinary skill of a POSA.

#### 1. Generation and playback of binaural and/or spatial audio

Methods for generation and playback of binaural and/or spatial audio were well known to a POSA at and before the purported priority dates of the Asserted Claims. These methods include, for example, the creation of zones for audio sources, the incorporation of head tracking to allow the user to perceive the sound as if originating from a specific location, the processing required for binaural and/or spatial audio and localized sound. Illustrative examples of such methods are disclosed in at least the following:

- **Andrea** at 2:37-40 ("A further object of the invention is to provide for a stereo headset or stereo earbuds with an integrated array of microphones utilizing an adaptive beam forming algorithm."), 10:35-43 ("The invention according to an embodiment may be an integrated headset system 200, a highly directional stereo array microphone with reception beam angle pointed forward from the ear phone to the corner of a user's mouth, as shown in FIG. 8. As shown in FIG. 8, headset system 200 is a circumaural headset. In some embodiments, a supra-aural headset using headphones 302 (shown in FIGS. 12 a-b), earbuds 303 (shown in FIG. 13), and/or one or more earphones may be utilized."), Figs. 8, 13, 28
- **Ballas 439** at 3:60-4:4 ("The head tracking system 104 measures the location and orientation of a user's head and provides the measured information to the computer system 102 which processes the audio signals using a head related transfer function (HRTF) filter 106 thus producing spatialized audio. The spatialized audio signals are amplified in an amplifier 108 and fed to speakers 110. The amplified signals are



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binaural in nature (i.e., left channel signals are supplied to the left ear and right channel signals are supplied to the right ear. The amplifier 108 generates sound that is loud enough to be heard in the nearest ear but generally too soft to be heard in the opposite ear.").), 4:21-26 ("FIG. 2 shows another embodiment of the present invention as in FIG. 1. Here, the processor 102 also performs the HRTF filtering functions. The audio source is generated and operates under the control of the computer system. The rest of the operation of FIG. 2 is similar to the operation as explained with respect to FIG. 1."), Figs. 1 and 2

- **Ballas 123** at 4:55-5:3 ("One aspect of the present invention, as alluded to above, deals with the manner in which the speakers are positioned in front of the ears of the user. For example, an apparatus may be used with a system that produces spatialized audio signals, wherein the apparatus includes a headpiece, speakers and an input system. The input system provides the spatially filtered audio signals from the HRTF filter to the speakers. Non-limiting examples of an input system include wires and wireless transmission systems. The speakers reproduce the sound from the spatially filtered audio signals such that the person hears the sound and perceives a maintained virtual location of the source of the sound. Further, the speakers are disposed with the headpiece so as to be positioned to augment the sound such that the perceived front-to-back reversals in a maintained virtual location of the source of the sound are reduced.")
- **Begault 2000** at 6 ("In addition, if the sound source should stay in a single location in virtual space, then its location relative to the listener's head position will also need to be synthesized and updated in real-time."), 12 ("Figure 1.8 shows a general configuration for the interface of a sound subsystem in a virtual reality system. The host computer calls on databases from the reality engine that describe the acoustic world, along with input from sensors such as trackers that allow updating the position of the virtual sound source in relation to the position of the head."), 13 ("3-D sound can contribute to the sense of immersivity in a 3-D environment. One might be able to work more effectively within a VR environment if actions were accompanied by appropriate sounds that seemingly emit from their proper locations, in the same way that texture mapping is used to improve the quality of shaded images."), 20 ("The technological context for implementing 3-D sound is directly tied to both the evolution of digital signal processing (DSP)… Changing the character of an input signal in the digital domain to create virtual spatial hearing experiences has been greatly facilitated by the development of DSP chips, particularly since they can be configured as filters that modify sound in the same way as in natural spatial hearing. Other advantages of DSP include relatively smaller hardware size, greater predictability of noise, and ease of reconfiguration—one can write different software specifications to the signal processor, rather than resoldering hardware components."), 39 ("In everyday perception we use head motion with our aural and visual senses in an attempt to acquire sound sources visually. Therefore, an important source of information for localization is obtained from head motion cues."), 99 ("Changing HRTF spectra as a function of head movement is generally considered to improve overall localization performance."), 100 ("Within a virtual reality or multimedia application, 3-D sound processing is almost always best accomplished digitally, using audio DSP chips to manipulate signal sources."), 100-101 ("Binaural cues (also known as stereophonic cues) are two


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different audio cues, one for each ear, that help to determine the position of sounds. Each ear hears a slightly different sound—different in time and different in level."), 132 ("any system that includes head or sound source movement necessitates finer resolution of spatial position than represented by the original measurements"), 133 ("If one of the perceptual requirements is to have virtual sound images remain fixed in virtual space independent of where one's head moves, a six degree-of-freedom tracker system is necessary, consisting of a source, sensor, and a hardware unit housing power supply, electronics, and RS-232 interface to send positional data to a host computer … Figure 4.38 shows the method used by a commercially available 3-D sound system for real-time placement of a virtual source to a fixed position, independent of the listener's movement. The head tracking system sends positional information to the host computer dedicated to the 3-D sound subsystem. An interpolation algorithm constantly checks this position against the two nearest azimuth and elevation positions in memory. The HRTF used at any particular moment is then the interpolation between these prestored values."), 139 ("As digital signal processing becomes cheaper, the number of methods and the complexity level for implementing synthetic reverberation based on either measurements or models of acoustic spaces both increase. Some of these methods have been worked into 3-D sound systems, where HRTF processing is applied not only to the direct sound but to the indirect sound field as well, resulting in a synthetic spatial reverberation. It is possible to apply the HRTF measurements paradigm illustrated previously in Figure 4.17 to obtain the impulse response of a reverberant space. The room, rather than the pinnae and the head, are measured through the use of a comparatively louder impulse or maximum-length sequence. One can either measure the room response with a single high-quality (to minimize noise and distortion) omnidirectional microphone or with several microphones at different locations. The result in the time domain will look something like the impulse response of the classroom shown previously in Figure 3.11."), 172 ("Figure 174 ("A simple audio equivalent to the graphic user interface (GUI) as described previously is only marginally useful. The concept of a computer workstation as not only a location for editing documents but also for communicating with databases and persons within the office adds a new dimension to the possibilities for 3-D sound. For instance, telephone communication can be handled though a computer via functions such as message recording and dialing. If the audio signal is brought into the computer and then spatialized, the communication source can be usefully arranged in virtual space. This feature becomes particularly important in multiconversation teleconferencing, where video images of the participants can be broadcast on the screen. Spatial audio teleconferencing has been described as an audio window system by Ludwig, Pincever, and Cohen (1990) … All types of sonic input could be directionalized to a specific location, controlled by the user. Furthermore, it is not necessary to place these audio sources in their corresponding visual locations; the audio spatial mapping can correspond to a prioritization scheme … Figure 5.12 shows a hypothetical GUI for arranging these various sound inputs in virtual auditory space in a manner configurable by each individual listener. The basic concept is to represent each form of auditory input iconically on the screen and then allow manipulation of the distance and relative azimuth of each source. The computer interprets the relative location of the icons on the screen as commands to a multiinput, 3-D sound spatialization subsystem."), 173-



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74 (describing “handysound” and an “interface called MAW” in which “[t]he visual arrangement of icons translate[d] into instructions for a 3-D audio subsystem”), Figs. 4.17, 4.38, 5.12

- **Bedingfield** at 3:25-34 (“An improved telephone or network-based communication system may more closely simulate an in-person conference setting. For example, a communication system may provide multi-channel sound to a listener by modifying a single channel signal provided by another participant's system. To further enhance the listener's experience, the communication system may assign each participant a virtual position within a virtual sound field. Each participant is heard by the listener in multi-channel audio based on the participant's virtual location in the sound field.”), 4:18-30 (“FIG. 1 illustrates an overall environment 100 for providing a synthetic audio placement to a listener 102. The environment 100 includes a number of participants, such as participants 104, 106, and 108. Although the environment only depicts three participants 104, 106, 108, any number of participants may be in connection with the listener 102. Each participant 104, 106, 108 may have a communication device 110, 112, 114, respectively. The communication devices 110, 112, 114 may be telephones, wireless phones, mobile phones, two-way voice devices, walkie-talkies, voice-over-IP (VoIP) devices, microphones, or other communication devices that permit multi-directional communication over a communication system 116.”), Figs. 1, 2, 3, 7, 14, 15
- **Hammershoi** at [0025] (“a set of earphones arranged to determine first and second positions related to positions of respective left and right ears of a listener, the sound pressures representing the binaural audio data.”)
- **Flaks 968** at 3:67-4:5 (“The listener 8 is wearing headphones 27 through which the 3D audio sound may be provided. In this example, headphones 27 include two audio speakers 37, one of which is worn over or next to each ear. The system 10 may provide the 3D audio signal, which drives the audio speakers 37.”), 4:10-11 (“To the listener 8, the sound in the 3D audio signal may appear to be originating from some virtual sound source 29.”), 5:6-18 (“FIG. 2 depicts an example block diagram of the motion capture and 3D audio system 10 of FIG. 1. The system 10 includes a depth camera system 20 and a computing environment 12. In this embodiment, the computing environment 12 has 3D audio generation 195. The computing environment 12 inputs depth information and RGB information from the depth camera system 20 and outputs a 3D audio signal to the audio amplifier 197. The audio amplifier 197 might be part of a separate device such as an HDTV, stereo system, etc. The 3D audio generation 195 may be implemented by executing instructions on the processor 192. Note that hardware executed implementations, as well as mixed software/hardware implementations, are also possible.”), 7:6-14 (“In step 306, a 3D audio signal is determined based on the listener's location in the room and one or more of the physical characteristics of the room. As one example, a number of sound paths between a virtual sound source and the listener can be determined. Furthermore, the physical characteristics of the room can be factored in. As one example, a sound reflecting off from a hardwood floor will be different than a sound reflecting from a carpet. Therefore, this may be factored in for a sound path having such a path.”), 7:22-24 (“In step 308, the 3D audio signal is



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provided. For example the 3D audio signal is provided to an audio amplifier 197, which is used to drive the headphones 27."), Figs. 2, 10-12

- **Billinghurst 1998** at 5 ("With this display configuration a wearable conference space could be created that allows remote collaborators appear as virtual avatars distributed about the user (figure 2.0). The avatars could be live video streams and as they speak their audio streams spatialized in real time so that they appear to emit from the corresponding avatar.")
- **Boustead** at 2:52-56 ("The spatialized audio signal may e.g. be a binaural audio signal which is rendered on headphones or loudspeakers at the terminal of the listener. Alternatively or in addition, the spatialized audio signal may be a multi-channel (surround sound) signal, e.g. a 5.1 or a 7.1 multi-channel signal."), 10:16-30 ("The generation of a binaural audio signal for each one of the downstream audio signals 124 may be performed by processing the (mono) downstream audio signal through a spatialisation algorithm. Such an algorithm could be the filtering of the samples of the downstream audio signal using a pair of head related transfer functions (HRTFs), in order to provide a left and right ear signal. The HRTFs describe the filtering that would have naturally occurred between a sound source (of the downstream audio signal) positioned at a particular location in space and the ears of the listener. The HRTFs include all the cues for the binaural rendering of the sound, such as interaural time difference, interaural level difference and spectral cues. The HRTFs depend on the location of the sound source (i.e. on the talker location of the downstream audio signal).")
- **Camci 2015** at Abstract ("First, we construct a bottom-up definition of an IVS, and examine its components, including space, sound objects, and users. We then describe a software we developed based on this model, and detail its functions in the construction of IVSs. Furthermore, we propose two approaches to the design of an IVS, namely an augmented reality and a virtual reality approach."), 118 ("Furthermore, the design approach to virtual soundscapes proposed in this paper adopts a landscape architecture model in which a two or three-dimensional terrain is populated with objects. Accordingly, using the IVS Software, which will be described briefly, the designer can furnish a virtual space with a variety of sound objects, and therefore synthesize sonic topologies."), 119 ("Moreover, the designer can also interact with the virtual soundscape in real-time, and alter the aural reality experienced by the user. An IVS therefore allows for the mutual participation of a designer and a user in creating a real-time, non-linear sound composition presented in the form of an [sic] spatial structure … Sound objects in an IVS can be either directional or omnidirectional. We label monophonic sound sources that propagate in all directions as omnidirectional sound objects. Such objects can display both uniform and non-uniform propagation characteristics. Conversely, directional sound objects have a limited field of projection as seen in Figure 1(b)."), 120 ("Once defined as a point in space, a sound object acts as a localized source. The spatial reach of a sound object is determined by its amplitude. Schafer describes acoustic space as the area over which a sound may be heard "before it drops below the ambient sound level" [3]. Accordingly, localized sound objects in an IVS occupy an acoustic space similarly to sounds in a natural environment. These objects exhibit a limited sound throw, and their audibility changes with the user's



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proximity to the object. On the other hand, zonal sound objects demarcate regions in the virtual space. The implementation of zonal sound objects was driven by an artistic need to have background or textural sounds that are independent of user position and orientation. These objects are audible only when a user wanders into a pre-determined area. Once in that area, the user hears the zonal sound object as an ambient sound. By changing the size of a zonal sound object, it can be made to cover the entirety of the virtual space or act as an excitable sound object of smaller size. The designer can use zonal sound objects to place omnipresent sounds, or sounds that are to be perceived as self sounds by the user. Another localization characteristic of a sound object is defined by whether it is stationary or moving. Sound objects in an IVS can be fixed in space or follow a motion trajectory defined by the designer."), Section 5.2 (discussing virtual Reality Approach), Figs. 1-2, 5-6

- **Chou** at 2:48-54 ("The term "sound source" is used herein to refer to a specific point in space that is audibly perceived as sourcing sound. The term "spatialized audio" is used herein to refer to a particular type of audio that when audibly rendered is perceived to have a three-dimensional (3D) effect in which sounds are perceived to emanate from one or more virtual sound sources that are located at specific points in space."), 4:49-5:6 ("Referring again to FIG. 1, the standalone environment sensing device 118 communicates with a standalone stereo listening device 120 which the person wears either over his two ears, or in his two ears, or in close proximity to his two ears. The listening device 120 includes a left side sound reproduction element 124 (such as a loudspeaker, and the like) which is physically placed either over, or in, or in close proximity to the left ear of the visually impaired person 102. The listening device 120 also includes a right side sound reproduction element 126 which is physically placed either over, or in, or in close proximity to the right ear of the visually impaired person. The listening device 120 may also include additional functionality (not shown) that will be described in more detail hereafter. It will be appreciated that the listening device 120 can be any of a variety of wearable audio reproduction devices such as a pair of stereo headphones which are worn over the person's two ears, or a pair of stereo earphones (also known as "earbuds") which are worn in the person's two ears, or a pair of bone conduction speakers which are commonly worn slightly in front of the person's two ears, among others. It will also be appreciated that the sensing device 118 can communicate with the listening device 120 via either a wired connection (not shown), or a wireless connection (not shown), or a combination of both of these types of connections."), 5:32-44 ("Referring again to FIG. 1, the sensing device outputs the spatialized audio representation to the standalone stereo listening device 120. The left side and right side sound reproduction elements 124 and 126 of the listening device render the spatialized audio representation. A spatialized audio sound field which includes the virtual sound sources emanates from the left side and right side sound reproduction elements, thus providing the visually impaired person with a spatial cue for each different object and passageway in his physical environment. The visually impaired person can use his auditory system to spatially interpret the sound field and thus auditorily determine the spatial geometry of his current physical environment.")
- **Cohen 1993 I** at Abstract ("The system, 'MAW' (acronymic for multidimensional audio windows), is a GUI (graphic user interface), integrating a graphic editor with a



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multidimensional spatial sound engine … Standard idioms for wimp (window, icon, menu, pointing device) systems are reinterpreted for audio window applications, including provisions for directionalized and nonatomic spatial sound objects. Unique features include draggably rotating icons, clusters, dynamically collapsible hierarchical groups of spatial sound objects, and an autofocus mode that is used to disambiguate multiple presence."), 468 (MAW is "an exocentric graphic mouse-based interface based on an extended model of free-field, two-dimensional (2D) spatial sound."), 469 ("A more sophisticated approach, spatial sound, employs technology that allows sound sources to have not only a left-right attribute (as in a conventional stereo mix), but up-down and backforth qualities as well. Spatial sound projects audio media into space by manipulating sound sources so that they assume virtual positions, mapping them into a perceptual envelope around the listener."), 470 ("'Audio windows' is an auditory-object manager, a user interface, or frontend, to a spatial sound system … The general idea is to permit multiple simultaneous audio sources, such as in a teleconference, to coexist in a modifiable display without clutter or user stress. The distribution of sounds in space is intended to realize some of the same kinds of benefits achieved by distribution of visual objects in graphic user interfaces … A powerful user interface would allow arbitrarily setting and adjusting the position of the audio channels, so the positions of the listener and sound sources may be constantly changing as they move around each other and a virtual room. By using an audio window system as a binaural directional mixing console, a multidimensional pan pot (a panoramic potentiometer controls the placement of a channel in a conventional stereo mix), users could set parameters reflecting these positions. Listeners altering these parameters could experience the sensation of wandering around a conference room, among the teleconferees. Members of the audience at a live or recorded concert could actively focus on a particular channel by sonically hovering over the shoulder of a musician in a virtual concert hall. Minglers at a virtual cocktail party might freely circulate … A mouse, trackball (a mouse on its back), or joystick would suffice for positioning objects in 2-space. One can imagine direct control of position (with a mouse, trackball, or DataGlove), steering control (with a return-to-center joystick), or programmed control (using automatic circulation). As long as visual tokens for the spatial sound objects are accessible through the workstation, they can be manipulated through the operations described above, via a suite of direct and indirect manipulation techniques (Cohen & Koizumi, 1992a). For example, a mouse-based system realizes indicating, highlighting, and relocating as pointing, clicking, and dragging. This paper describes a system that implements graphic control of audio windows, by reinterpreting wimp conventions to handle an extended spatial sound model"), 471 ("MAW includes a GUI, employing visual representations of sound elements manipulated through a workstation, integrating graphic and audio windows by manipulating spatial audio channels via graphic control … The graphic representation of MAW's virtual room is an aerial projection, a 2D bird's-eye view. This perspective flattening was implemented partly because of its suitability for visual display on a workstation monitor."), 472 ("The system allows a variety of iconic styles, including any combination of static pictures [which might be head-and-shoulder snapshots (as in Fig. 3) or top-down (as in Fig. 6)], symbolic icons (as in Fig. 6), overlaying sound field density plots (as in the right column of Fig. 4), and textual labels (as in Fig. 3). These



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representations may be switched 'on-the fly,' in response to user preference."), 473 ("Sinks and sources may be repositioned, individually or in groups. (Association is discussed later in Section 2.5.) Since the spatial sound object states include both angular and rectangular attributes, they may be rotated as well as translated. This repositioning may be by either direct or indirect manipulation, may be (rectilinearly or latticed) constrained or unconstrained, may be continuous or discrete, nonconvergent or convergent to some target, and may be absolute or relative to the starting position of the icon (Cohen 8c Koizumi, 1992a)."), 475-76 ("[A] cluster feature organizes separate input channels that share a single spatializing channel. One application might involve zooming effects. Distant sources would not be displayed; but as it approaches, a cluster would appear as a single point; only to disassociate and distribute spatially as it gets closer. This focus allows navigation in arbitrarily large spaces, assuming a limited density of point sources. Alternatively, with limited spatializing resources, a user might choose to group a subset of the (less pleasant or less important) channels together, stacking them in a corner or closet."), 476 ("With the appropriate interface, one could grab onto an orchestral cluster, for instance (shown as part of the concert in Fig. 5), separate the different instruments, grab one of those instruments, and move it across the room … A collection of MAW objects, including any number of spatial sound objects and graphic elements, may be grouped and then moved, rotated, and scaled in ensemble (like a chorus of distinct but coupled voices). As a special case of grouping, MAW also implements clusters. When clustered, the selected spatial sound elements merge into one another, aligning and converging until they are spatially and graphically indistinguishable. Unlike members of a group that maintain their constellation, members of a cluster temporarily collapse into a bundle, subsuming their individual identities in a collective display. The last-selected icon is designated as the model: when the cluster operation is invoked, the other selected icons dynamically approach it, converging on its position, orientation, and display attributes."), 477 ("MAW also features a 'schizophrenic' mode, allowing multiple sinks in the same or different conference rooms, explicitly overlaying multiple audio displays. A simple teleconferencing configuration typically consists of several icons, representing the distributed users, moving around a shared conference space. Each of these icons represents a source, the voice of the associated user, as well as a sink, that user's ears … If the sinks are distributed in separate conference rooms, each source is localized only with respect to the sink in the same room. If multiple sinks share a single conference room, an 'autofocus' mode is employed by anticipating level difference localization, the tendency to perceive multiple identical sources in different locations as a single fused source."), 478 ("This research explores the integration of graphical and audio window systems. MAW is a 'moving sources/moving listener' type interface (Cohen & Ludwig, 1991a,b) in which users can arrange both themselves and spatial sound objects in a virtual free-field … MAW provides ways of manipulating the spatial sound objects as atoms, groups, and hierarchical trees (nested clusters). The cluster feature makes the interface not quite WYSIWYG (what you see is what you get), but this hiding of information is necessary for hierarchical abstraction. In order to support full-duplex conferencing, a large number of audio channels must be channeled through audio imaging processors. Other applications, including voicemail, hypermedia, and music, require an arbitrarily large number of separately spatialized sonic channels. For



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all of these, and any task involving terminal audio management, spatial data organization, or scientific auralization (Kendall, 1990), a clustering mechanism is useful, both as a way of imposing a logical hierarchy on many sources, and, in conjunction with an audio switching matrix, as a way of conserving channels … WIMP interface conventions can be seamlessly extended to manage 2D spatial sound objects, with the enhancement of draggably rotating icons, allowing nonomnidirectional sources and sinks; extension of chorded arrow combinations, enabling indirect spatial sound object manipulation (by allowing rotation, for example); and clusters, whose order-sensitive selection defines hierarchically collapsing groups of spatial sound objects. The direct manipulation object-command (noun-verb) syntax is well suited for moving sources and sinks. Mode indicating cursors, animated icons (Baecker, Small 8c Mander, 1991) during dynamic tracking, and clustering effects contribute to the complete suite of manipulation techniques available."), 479 ("The explored models give users a telepresence into metaphorical space. Some of the features implemented find close approximation in visual or physical media; others elude analogy. But since it depends on perceptual rather than symbolic processing, Maw requires minimal instructions or training. It provides a testbed for exploring the potential of the emerging technology and for researching relevant human factors issues. Using systems like Maw for audio windowing can be likened to sonic (analytic) cubism: it presents several audio perspectives (on an assembled conference or concert) simultaneously."), Fig. 3

- **Ermilov** at [0100] ("According to another illustrative feature, the system 102 may use three-dimensional sounds to announce the presence of some types of IOIs, such as some types of contextual IOIs. A three-dimensional sound refers to a sound that the user perceives as emanating from a particular location (or locations) within physical space. In reality, however, the audio information is presented to the user via the headset 108 and has no physical origin within the environment. As will be described below in Section D, the system 102 can achieve the above result through the use of Head-Related Transfer Functions (HRTFs), in conjunction with different types of wideband audio sounds. In other implementations, the system 102 can use other techniques and technologies to create a three-dimensional audio effect (instead of HRTFs or in addition to HRTFs), such as Ambiophonics, Ambisonics, wave field synthesis etc."), [0276] ("In one implementation, the sound generation module 414 generates three-dimensional sounds that convey wideband audio information. Wideband audio information is audio information that includes a wide distribution of audio frequencies, e.g., in one implementation, in the range of 300 Hz to 3.4 kHz. Further, the individual three-dimensional sounds are expressive in nature to further emphasize their directionality. For example, one such three-dimensional sound may resemble a gust of wind blowing from left to right or from left to right. Other properties of the audio information (besides its HRTF-based directionality) may contribute to its expressiveness, such as by providing variations in volume, tone, reverberation, looping frequency (for repeating sounds), etc. All of these factors contribute to a realistic perception that sound is originating from a particular location (or locations) in physical space.")
- **Etter 419** at [0053] ("FIG.8 shows an illustrative environment for providing binaural audio-visual rendering of a sound source in a video teleconferencing application using



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a video display screen and a dummy head in the subject conference room, in accordance with a fourth illustrative embodiment of the present invention. The figure shows two rooms—conference room 801 and remote room 802. Remote room 802 contains remote participant 812 who is viewing the activity (e.g., a set of conference participants) in conference room 801 using video display screen 811 and listening to the activity (e.g., one or more speaking conference participants) in conference room 801 using a headset comprising right speaker 809 and left speaker 810."), [0063] ("Binaural mixer 1005 then generates a pair of stereo binaural audio signals, in accordance with the principles of the present invention and in accordance with an illustrative embodiment thereof, which will advantageously provide improved matching of auditory space to visual space. In accordance with one illustrative embodiment of the present invention, viewer 1012 uses headphones (not shown in the figure as representing a different illustrative embodiment of the present invention) which comprises a pair of speakers (a left ear speaker and a right ear speaker) to which these two stereo binaural audio signals are respectively and directly provided."), Fig. 8.

- **Gardner** at 12:51-13:5 ("For example, a source behind an occluding wall might be muffled by a filter that reduces high frequencies. After the filter 1115, the sound is scaled by a gain module 1120 according to the distance between the source and the listener. The scaled sound is then spatialized by filtering with a pair of head-related transfer functions (HRTFs) 1125 L, 1125 R, which reproduce spatial localization cues. Filtering with the HRTFs 1125 produces binaural stereo outputs. Along the reverb path 1105, the monophonic input sound is processed by a reverberator 1130 through a reverb gain module 1135 whose value depends on the reverberant qualities of the virtual space and the distance between the source and the listener. The stereo reverb output is summed with the binaural output from the direct path. The final stereo output will sound like the input sound localized at a desired direction, at a desired distance, with environmental effects such as Doppler shift, object occlusion, and room reverberation. Additional audio effects may be applied to each conference input in series with the delay and occlusion filter. As described earlier, one such audio effect may simulate the sound of a virtual communications device such as a walkie talkie.")
- **Jarvinen** at 15:25-31 ("In an example embodiment, a user may be utilizing a multimedia device such as, for example, apparatus 50 or communication device 90 which may be playing spatial audio output from one or more speakers (e.g. speakers 79, speakers 99 (e.g., headphones, loudspeakers, etc.) while the user wishes to manipulate characteristics of the audio objects in order to improve the listening experience.), 4:64-5:4 ("In an alternative example embodiment, an audio object(s) may be a spatial audio object(s) corresponding to an audio source(s) with additional side information that forms the audio object(s). The audio source(s) may be an audio signal(s) (e.g., a spatial audio signal(s)) and the side information may include one or more properties such as, for example, spatial position, source orientation, etc.")
- **Jang** at 1:20-24 ("The present general inventive concept relates to an apparatus and a method to perform sound processing in a virtual reality system, and more particularly to a sound processing apparatus and a sound processing method that can process sound in a focus area of a virtual reality system differently from sound in an un-focus area."), 2:32-47 ("Features and/or utilities of the present general inventive concept may be


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realized by an apparatus to perform sound processing in a virtual reality system, the apparatus including a sound processing unit to process and produce sound output in sound areas divided into a focus area within a predetermined visual field and an un-focus area out of the predetermined visual field in a virtual reality space for a sound source, the sound output of the focus area being processed and produced differently than the sound output from the unfocused area. The apparatus may further include a control unit to divide the sound areas into the focus area and the un-focus area, and to control the sound output of the sound processing unit such that a volume of sound in a first space is gradually decreased while a volume of sound in a second space is gradually increased when a space shift from the first space to the second space in the virtual reality space is detected."), 3:39-48 ("The focus area may correspond to an area in the virtual environment adjacent to a predetermined point. The predetermined point may correspond to a character usable by a user, and the perspective of the character may be the perspective of a user. The focus area may correspond to a location in the virtual environment that is in the immediate foreground of the character visual perspective of the character. The non-focus area may include an area outside the immediate foreground of the character's visual perspective of the virtual environment."), 5:46-48 ("FIG. 6 illustrates a sound mixing process to provide virtual reality sound by a virtual reality apparatus according to an embodiment of the present general inventive concept"), 6:35-7:2 ("For example, a user may interact with the virtual environment using an avatar. The user may see, hear, and otherwise sense the virtual environment from the perspective of the avatar. Upon receiving the virtual reality space information, the control unit 114 may access the storage unit 102 to access audio, sound, and/or other sensory data to output to the user to represent the virtual environment. According to the present embodiment, the control unit 114 may control the sensory data to correspond to the virtual environment. The control unit 114 may mix sensory data of the virtual environment including a user's avatar or character and otheravatars, characters, objects, or features of the virtual environment. The control unit 114 may divide the sensory data into a focus area and non-focus areas and may control the sensory processing unit 118 to output sensory elements of the focus area differently than sensory elements of the non-focus areas. For example, the control unit 114 may instruct the sensory processing unit 118 to cause audio elements of the non-focus areas to be muffled or quieter than audio elements of a focus area. In the case of visual sensory elements, the control unit 114 may instruct the sensory processing unit 118 to cause visual elements of non-focus areas to be less clear, blurred, or dark and visual elements of the focus area to be detailed and clear. The control unit 114 may detect whethera change of virtual space has occurred in the virtual environment, and may control the sensory processing unit 118 to correspond to the change in space. The control unit 114 may instruct the sensory processing unit 120 to fade out sensory elements of the first space and to fade in sensory elements of the second space. The control unit 114 may instruct the sensory processing unit 118 to first fade in sensory elements of a focus area of the second space and to later include sensory elements of non-focus areas of the second space."), 7:14-37 ("The virtual reality server 100 may include a control unit 104, a storage unit 102, and a communication unit 106 to provide predetermined virtual reality environments, such as a virtual reality game, and various sound sources provided in the virtual reality environments to the virtual reality



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apparatus 110 of the user … The control unit 104 controls the general operation of the virtual reality server 100 and provides sound sources as well as image sources occurring in the virtual reality environments to the virtual reality apparatus 110. The control unit 104 may receive an input of a selected virtual reality character from the user to which the virtual reality environment is provided, check sound source information on other characters and other objects existing in the virtual reality spaces already stored in the storage unit 102, and provides the virtual reality apparatus 110 with sound sources occurring in real time according to the relative locations or situations of the character in the virtual reality environment."), 8:21-24 (FIG. 2 is based on a situation in which a character, or actor, 200 of the user of the virtual reality apparatus looks at a first companion 220 while a second companion 230 and a third companion 240 look at the character 200.), 8:36-49 ("The division between the focus area and the non-focus areas in FIG. 2 is only an example and may be modified in various ways according to the characteristics and/or topography of the virtual area at which the characteris located in the virtual reality space. For example, while the dividing of sound areas is described with respect to a character 200 and companions 220, 230, and 240, the "companions" need not be players or personages. Rather, each divided focus or non-focus area may contain any number of virtual objects represented by sensory data that may include audio and visual data, for example. Further, at least one of the focus area and the non-focus areas may be divided into multiple areas in the virtual reality space according to a predetermined priority in controlling the volume of the sound or the left-right balance."), 9:11-17 ("The shift from the first space to the second space may occur in various ways, for example, when the control unit 114 detects a key input of the user for character movement through a key input unit (not shown) of the virtual reality apparatus 110 or when the control unit 114 detects scene change due to space shift in a video output (not shown)."), 9:45-50 ("Then, in operation 403, the control unit 114 divides the sound area of the virtual space into a focus area and non-focus areas. In operations 401 and 403, the identification of the virtual space and division of the sound area of the virtual space are performed according to a predetermined scheme."), 10:59-60 ("FIG. 6 illustrates a space shift in a virtual environment from a basketball court 600 to a conference room 610."), 11:64-12: ("For example, if a user's character moves from a basketball court to a conference room, visual, audio, or tactile elements of the basketball court may decrease in magnitude, and visual, audio, or tactile elements of the conference room may begin to be transferred to a virtual reality device or a portion of the virtual reality device. Transferring the sensory output data of the second space may include transferring data from a source outside the virtual reality device or from a storage unit within the virtual reality device to a control unit."), Figs. 2, 6.

- **Jerald** at 240 ("For more realistic audio and where auditory cues are especially important, auralization—the rendering of sound to simulate reflections and binaural differences between the ears—can be used. The result of auralization is spatialized audio—sound that is perceived to come from some location in 3D space (Section 8.2.2). Spatialized audio can be useful to serve as a wayfinding aid (Section 21.5), to provide cues of where other characters are located, and to give feedback of where the element of a user interface is located.")



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- **Knappe** at 8:1-14 ("Channel mappers 96 and 98 can position the apparent location of their assigned conferencing endpoints within the presentation sound field by manipulating ITD and/or ILD for their assigned voice data channels. If a conferencing endpoint is broadcasting monaurally and the presentation system uses stereo, a preliminary step can be to split the single channel by forming identical left and right channels. Or, the single channel can be directly mapped to two channels with appropriate ITD/ILD effects introduced in each channel. Likewise, an ITD/ILD mapping matrix can be used to translate a monophonic or stereophonic voice data channel to, e.g., a traditional two-speaker, 3-speaker (left, right, center) or 5.1 (left-rear, left, center, right, right-rear, subwoofer) format.")
- **Li 305** at 5:59-6:17 ("The method and the configurable 3D sound system disclosed herein also generates a configurable 3D binaural sound from a sound input, for example, a stereo sound or a multi-channel sound. In this method, the 3D sound processing application acquires a sound input, for example, a stereo sound or a multi-channel sound in one of multiple formats from multiple sound sources positioned in a 3D space. In an embodiment, the microphone array system is replaced by multiple microphones positioned in a 3D space to record the sound input. The microphones positioned in the 3D space record a sound input, for example, a stereo sound or a multi-channel sound in multiple formats. The microphones are operably coupled to the 3D sound processing application. In another embodiment, the 3D sound processing application acquires any existing or pre-recorded stereo sound or multiple track sound. The 3D sound processing application segments the recorded or the pre-recorded sound input into multiple sound tracks. Each sound track corresponds to one of the sound sources. In an embodiment, the 3D sound processing application segments the recorded or pre-recorded stereo sound into multiple sound tracks by applying pre-trained acoustic models to the recorded or pre-recorded stereo sound to recognize and separate the recorded or pre-recorded stereo sound into sound tracks. The 3D sound processing application is configured to train the pre-trained acoustic models based on pre-recorded sound sources.")
- **Lovitt** at [0014] ("It may be desirable in some instances (such as during video game play, for example) to enable a listener of a sound system to perceive that sounds produced by one or more speakers appear to originate at a particular location in three-dimensional acoustic space. In some embodiments, headphones may be utilized to enable the listener to perceive that sounds produced by the headphones originate at a particular location in three-dimensional acoustic space. Typical headphones may comprise, for each ear, one or more acoustic transducers configured to provide audio signals to the ear. Such "three-dimensional audio output" comprises audio output that provides the illusion that sound is coming from a location in three-dimensional acoustic space that may or may not correspond to the location of the speaker(s) producing the sound."), [0033] ("The first electronic gaming machine 14 and/or the display device 64 may also include a microphone system 78 that includes one or more microphones. In this manner, the first electronic gaming machine 14 and/or the display device 64 may receive audio input from a user 72 and/or other sources. In some embodiments, the first electronic gaming machine 14 may use such audio input to infer speaker locations in a physical environment and/or determine a shape, configuration, object location, etc. of



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a room."), [0038] ("In the illustrated example of FIG. 2, the interactive digital environment of game 208 includes virtual space sound source 238 (e.g., weapon muzzle brake of a user-controlled weapon) and virtual space sound source 242 (e.g., tank muzzle brake). As used herein, the term "virtual space sound source" refers to any element (e.g., scenery, user-controlled characters, non-user-controlled characters, etc.) generated by gaming console 212 with which sound is programmatically associated (e.g., "originates" from). In other words, each virtual space sound source includes one or more associated sounds such that, during interaction with the virtual environment, one or more of the associated sounds are programmed to be "output" from a particular virtual space sound source.")

- **Mangiat** at [0143] ("As another example, FIG. 16A shows a bird's eye view 1600 a of a user's environment. While the wearable system is playing a piece of music, the wearable system may present five (in this example) visual graphics 1610 a, 1620 a, 1630 a, 1640 a, and 1650 a, each associated with a stem track of the music. In this example, the five visual graphics are placed at different locations of the user's environment. The user 1670 a may stand in the middle of the room and be surrounded by the five visual graphics. At a given time, the user 1670 a may see a subset of the visual graphics in his FOV even though there are other visual graphics in his environment. For example, the user 1670 a may see visual graphics 1630 a and 1640 a at the same time in his FOV, but not the visual graphic 1610 a because the visual graphic 1610 a is behind the user 1670 a. As the user 1670 a changes his pose, other visual graphics may become visible. For example, when the user 1670 a turns around, the user can perceive the visual graphic 1610 a but the visual graphics 1630 a and 1640 a may no longer be perceivable because they are outside of the user's FOV."), [0144] ("As described with reference to FIG. 13, as the user 1670 a moves around in his environment, the appearance of the visual graphics may change accordingly. For example, as the user 1670 a approaches the visual graphic 1610 a, the wearable system may present more details of the visual graphic 1610 a. The wearable system can also emphasize the visual graphic 1610 a, for example, to make it appear bigger and brighter, when the user is looking at the visual graphic 1610 a. However, as the user turns to a different direction, the visual graphic 1610 a may reduce the size or brightness, while another visual graphic (such as 1650 b) in the user's direction of gaze may be emphasized (as shown in FIG. 16B)."), [0145] ("As another example, the user 1670 a may initially perceive visual graphics 1630 a and 1640 a in his FOV. But as the user 1670 a moves closer to the visual graphic 1630 a, the visual graphic 1640 a may be outside of the user's FOV and therefore the user 1670 a may no longer be able to perceive the visual graphic 1640."), [0146] ("In certain situations, the audio content may remain the same (e.g., because the user has locked the spatial locations of the stem tracks) although the visual graphic may change based on the user's location. For example, the wearable system may make the visual graphic brighter when it's closer to the user 1670 a while weaker when it's away from the user 1670 a. In the meantime, the wearable system may be configured not to update the stem track associated with the visual graphic (such as not changing the volume of the stem tack) as the user 1670 a moves around."), [0147] ("In other implementations, as the user 1670 a moves around in his environment, the audio content in the audio file may be updated. For example, as the user 1670 a moves closer to the location of the visual graphic 1610 a, the sound



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associated with the visual graphic 1610 a may become more prominent. Similarly, the user 1670 may initially face the visual graphics 1630 a and 1640 a. As a result, the stem tracks associated with the visual graphics 1630 a and 1640 a may be played as if they are in front of the user 1670 a. However, as the user 1670 a turns around, the stem tracks associated with the visual graphics 1630 a and 1640 a may be updated as if they are played behind the user 1670 a."), [0148] ("FIGS. 16A and 16B also illustrate examples of directionalities of sound sources. As shown in the bird eye views 1600 a and 1600 b, the stem tracks 1610 a, 1620 a, and 1650 b may only be audible in a few directions. For example, the stem track 1610 a is only audible in the region 1612 a; the stem track 1620 a is only audible in regions 1622 a and 1624 a; and the stem track 1650 b (shown in FIG. 16B) is only audible in regions 1652 b, 1654 b, 1656 b, and 1658 b."), [0149] ("When a user is inside of the audible regions, the user can perceive the sounds associated with the audible regions. For example, in FIG. 16B, when the user is inside of the region 1652 b, the user can perceive the sound associated with the visual graphic 1650 b. However, if the user is outside of the regions 1652 b, 1654 b, 1656 b, and 1658 b, the user may not be able to hear the sound associated with the visual graphic 1650 b."), [0150] ("In some implementations, the audible regions for the stem tracks may overlap. As shown in FIG. 16A, the regions 1624 a and 1612 a overlap at region 1672 a. As a result, when the user 1670 a is within the region 1672 a, the wearable system may present a mixture of the sounds associated with the visual graphics 1620 a and 1610 a. For example, the audio mix may reflect the spatial location of the sounds. In the view 1600 a, because the user is facing the visual graphic 1610 a, the sound associated with the visual graphic 1610 a may appear to be in front of the user while the sound associated with the visual graphic 1622 a may appear to be to the left of the user in the audio mix."), [0151] ("The wearable system may display the visual graphic 1610 a alone or in combination with visual graphic 1620 a in the FOV. For example, although the user may hear the audio mix for sounds associated with visual graphic 1610 a and 1620 a when the user is in the region 1672 a, the user may only perceive the visual graphic 1610 a. In other implementations, wearable system may present both visual graphics (1610 a and 1620 a) since the audio mix includes the sounds associated with both visual graphics."), [0152] ("In some embodiments, the wearable system may be configured to only display visual graphics associated with the stem tracks when the user is within the audible regions of the stem tracks. As an example, the wearable system may display the visual graphic 1650 b when the user is within the regions 1652 b, 1654 b, 1656 b, and 1658 b. As the user approaches the visual graphic 1650 b, the wearable system may show the visual graphic 1650 b to be a larger and brighter. In the meantime, the wearable system may optionally increase the volume of the visual graphic 1650 b in the audio mix. However, when the user is outside of audible regions, the wearable system may be configured not shown the visual graphic 1650 b, even though in some situations, the user is looking at the direction of visual graphic 1650 b."), Figs. 16A-16B

- **Marks** at 2:65-3:2 ("In some embodiments, the method further includes receiving selection of a listening zone in the virtual reality environment by the spectator, wherein selection of the"), 14:1-28 ("In some embodiments, spectators can be provided with controls that allow the spectator to identify specific listening zones within the virtual reality environment. The listening zones allow spectators to select where in the virtual



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reality environment they wish to listen from. What this means is that the spectator is essentially provided with listening audio and acoustics that mimic a situation where the spectator would actually be present in the scene from that specific location. By way of example, if a spectator is viewing HMD content that includes a building across the street, relative to the viewing location, the spectator can identify some location in the building, e.g. the second-story where a person is standing, and select to listen at that location. This functionality provides a listening teleportation for the spectator, which allows the spectator to listen to the content of audio, and acoustics as if the spectator were sitting or standing in the second-story building. The audio and acoustics, in one example, would essentially magnify the audio sounds that would be present at the second-story location of the building, and reduce the sounds that are further away from that virtual location. In some embodiments, the spectator can from time to time, select different locations within the environment for being the primary listening zone. In still other embodiments, the listening zone can also be adjusted to be the same listening zone of the HMD player. A spectator can be provided with switchable selection capabilities, so as to identify where in the virtual environment the spectator wishes to listen."), 15:34-48 ("In this particular example, the spectator is an HMD spectator 150. The HMD spectator 150 can be provided with specific viewing spots at different times within the activity shown of the virtual reality environment 450. For instance, as the HMD player 100 traverses or moves about the virtual reality environment 450, different content is shown, and based on the content that is being shown, different spots are selected for viewing consumption by the spectator or spectators. By way of example, the HMD spectator 150 is provided with a sequence of spots, such as spot 1 at time t=0, spot 3 at time t=l, spot 2 at time t=2, and so on. Therefore, depending on where the HMD player 100 traverses, different spots may be selected dynamically for the spectator."), 20:9-60 ("FIG. 10 illustrates an example where an HMD player 100 may be interacting with a virtual reality environment 450, and different types of activity are occurring therein. In this example, the virtual reality environment 450 includes a truck 922, a building 920, a car crash 924, and various other types of content. In one configuration, different activity will also produce different sounds that are being generated and listened to by the HMD player 100 by way of headphones 940. If the perspective of the HMD player 100 is from a first-person point of view, the sounds being generated within the virtual reality environment 450 will be relative to the position of the HMD player 100. In this example, the car crash 924 may sound further away and possibly the HMD player 100 may not be able to listen to conversations had in the various listening zones 1, 2, and 3. If the HMD player 100 were to approach those listening zones, the sounds for those listening zones would then change, along with any associated acoustics to provide a realistic listening environment, as if the player were actually in the virtual reality scene. From the point of view of the spectator 150, the spectator 150 may be provided different points of view into the virtual reality environment 450, as described above. In some configurations, the spectator 150 may desire to listen in at different listening zones. The spectator may be provided with functionality to select different listening zones, which would impact the audio provided to the spectator 150, and listened to via headphones 942. By way of example, if the spectator 150 desires to listen in to listening zone 1, the spectator 150 may be able to hear a conversation had by virtual reality players or artificial intelligence (AI)



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characters in listening zone 1. The spectator 150 can therefore be placed in that listening zone, and sounds coming from other listening zones will be generated to the spectator 150 as if the spectator 150 were in the listening zone 1. The same is true if the spectator 150 decides to select the listen to listening zone 2, which may be a conversation being had by a person standing inside of a three story office building 920. And also, the spectator 150 can similarly listen to listening zone 3, to hear what's going on with respect to the car crash 924. In this example, the spectator 150 is also using an HMD 102. The spectator 150 may be using glove gestures 930 for selecting the listening zones. In other embodiments, the spectator can be using a controller, a keyboard, hand gestures without gloves, voice input, gaze input, etc., to direct which listening zone is interesting to the spectator 150. Still further, the spectator can simply be viewing the content from a display screen connected to a website, such as a twitch-type site. In some embodiments, a personal computer (PC), game console, smart phone, tablet computer, etc., may be used to view the virtual reality environment 450, which is being played by the HMD player 100."), 21:14-16 ("These functionalities provide for dynamic and enhanced spectating abilities, that will enhance the experience a spectators viewing HMD navigated content."), Fig. 10

- **Miller 466** at 23:48-59 ("The device can provide audio output to the user using a speaker system (1603), which can include noise cancellation (1604) implemented through mechanical dampening, software or electrical feedback and/or feedforward controls, or other means. Content and properties of the audio output are determined by software and/or circuitry. For example, audio can be "spatially rendered" to make the user perceive various virtual audio sources as located in various x,y,z locations in world space—this is using a software algorithm that controls both the audio output as well as head-tracking inputs and a head-related transfer function (HRTF) to simulate acoustics.")
- **Najaf-Zadeh** at 4:55-65 ("Embodiments of the present disclosure provide an adaptive ambisonic binaural rendering framework for stereoscopic 3D VR or AR applications on the HMD 100. For VR experience using the HMD 100, the user's head motion, i.e., the movement of the HMD 100, is tracked using sensor(s) 165 in the HMD 100 and used to control the binaural rendering. In this disclosure, ambisonic signals are rotated according to the HMD 100 orientation and then mapped to virtual speakers located at fixed positions. The rotated ambisonic signals and a fixed set of Head-Related Transfer Functions (HRTF) are used to produce ear signals."), Fig. 5
- **Osman** at 12:47-54 ("Sound Projection module 716 modifies sound signals, intended for delivery to a sound system, in order to perform sound localization, such that the user receiving the modified sound signals will have the impression that the sound emanates from the intended location. Sound projection module 716 uses the location information provided by device position tracking module 724 and head tracking module 738 to modify the sound signals."), Figs. 8A-11
- **Otto 440** at 10:62-11:3 ("A sound effect simulates the fire of the cannon from the actual location of user 406b. The firing shot is heard first, and is followed by the sound of the cannonball as the cannonball travels through the air from the location of player 406b to the location of player 406a. As the cannonball travels through the air, the sound



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increases in intensity, as in real life. Finally, the explosion is heard when the cannonball hits the target, and if the target is near the user, the sound will be delivered with high volume."), 11:14-41 ("The binaural mode signal processing chain, shown in FIG. 8, consists of multiple discrete sources, in the illustrated example, three sources: sources 201, 202 and 203, which are then convolved with binaural Head Related Transfer Function (HRTF) encoding filters 211, 212 and 213 corresponding to the desired virtual angle of transmission from the speaker to the user. There are two HRTF filters for each source—one for the left ear and one for the right ear. The resulting HRTF-filtered signals for the left ear are all added together to generate an input signal corresponding to sound to be heard by the user's left ear. Similarly, the HRTF-filtered signals for the user's right ear are added together. The resulting left and right ear signals are then convolved with inverse filter groups 221 and 222, respectively, with one filter for each speaker element in the speaker array, and the resulting total signal is sent to the corresponding speaker element via a multichannel (12×DAC) sound card 230 and class D amplifiers 240 (one for each speaker) for audio transmission to the user through speaker array 250. Each of the speakers in the array (twelve in this example) emits a component that, when combined with the other speakers, produces an audio beam that is configured to be heard at one of the user's ears. In this way, discrete signals meant for the right and left ears can be delivered over optimized beams to the user's ears. This enables a highly realistic virtual surround sound experience without the use of headphones or physical surround speakers."), Fig. 9

- **Otto 526** at Abstract ("In a binaural mode, a speaker array provides two targeted beams aimed towards the primary user's ears—one discrete beam for the left ear and one discrete beam for the right ear. In a privacy mode, a privacy zone could be created in which a primary audio beam would deliver a signal of interest to the user while secondary beams would be aimed at different angles to provide a masking noise.")
- **Pedersen** at 3:53-65 ("In accordance with the new method, a monaural audio signal emitted by a specific source, such as monaural audio signal from a spouse microphone, a media player, a hearing loop system, a teleconference system, a radio, a TV, a telephone, a device with an alarm, etc., is filtered with a binaural filter in such a way that the human perceives the received monaural audio signal to be emitted by the respective source positioned in the selected direction in space."), 6:20-30 ("Further separation of sound sources may be obtained by provision of further binaural filters so that other monaural signals, such as a second monaural signal received from a second spouse microphone, a media player, a hearing loop system, a teleconference system, a radio, a TV, a telephone, a device with an alarm, etc., is filtered with the second binaural filter in such a way that the user perceives the received second monaural audio signal to be emitted by a sound source positioned in a second position and/or arriving from a second direction in space different from other selected perceived positions and directions.").
- **Sawyer** at [0025] ("Certain embodiments of the present invention comprise a trackable head-mounted display ("HMD") with at least three degrees of freedom in an operating space and optionally one or more sensors with at least two degrees of freedom of positional tracking. The HMD and the optional sensors provide sensory input to a controller, which in turn provides sensory feedback to the HMD or another output



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device. Without limitation, the HMD may be tethered to a stationary computer (such as a personal computer ("PC"), laptop, or game console), or alternatively may be self-contained (i.e., with some or all sensory inputs, controllers/computers, and outputs all housed in a single head-mounted device).")

- **Schroder** at 4:11-25 ("In addition to the method for avoiding in-head localization, rotational movements of the head are therefore evaluated and the signals for the left and right ears are altered such that a stable virtual position for sound sources in space becomes established. This situation is shown schematically in Figures 7 and 8. The initial situation in Figure 7 corresponds to Figure 5. In Figure 8, the listener has changed his position. The associated change in the signals for the left and right ears is illustrated by the signals L' , L' (HRTF) , R' , R' (HRTF) . Despite the coincidentally moving loudspeakers 8, 9, the aural event is perceived as coming from the original direction 6.")
- **Seligmann** at Abstract ("The system generates a three-dimensional sound space having a plurality of sound sources playing at a same time, wherein each of the plurality of sound sources is assigned a respective location in the three-dimensional sound space relative to one another, and wherein a user is assigned a current location in the three-dimensional sound space relative to each respective location. Next, the system receives input from the user to navigate to a new location in the three-dimensional sound space. Based on the input, the system then changes each respective location of the plurality of sound sources relative to the new location in the three-dimensional sound space."), 2:44-51 ("The system can receive the input via a mouse, a touch screen, a touchpad, a keyboard, a camera, a photo-capture device, a voice-input device, a motion capture device, a system state, a device state, a sensor, a joystick, a software control, a control pad, an external event, etc. Moreover, the input can be text, audio, a gesture, a movement, a selection, a click, a motion, a command, an instruction, an event, a signal from an input device, etc. … as another example, the user can navigate to the new location by physically moving in the direction of the new location as perceived by the user in the three-dimensional sound space."), 6:56-9:16 (describing Figure 3 embodiment), 10:31-50 ("FIG. 6 illustrates an example user experience in a three-dimensional sound space with multiple sound sources. Here, the user's experience navigating a three-dimensional sound space is illustrated by reference to what the user 602 perceives when navigating a college building 600. The college building 600 includes classrooms A-F. The classrooms A-F represent sound sources in a three-dimensional sound space, as each classroom generates sound in different dimensions, stemming from the professor's class lecture. Here, the user 602 is able to listen to the sound from the classrooms A-F at the same time. However, the sound perceived by the user 602 from the different classrooms will differ based on the proximity and/or location of the user 602 relative to the different classrooms. For example, when the user 602 is at position 1, she can perceive the lectures from classrooms A-D to be closer and/or more prominent, and the lectures from classrooms E and F farther and/or dimmer. Thus, the user 602 will be able to listen to the English, Math, History, and Art lectures from classrooms A-D, and at the same time will hear dimmer or faded poetry and science lectures from classrooms E and F."), 10:51-67 ("Further, the user 602 can go inside a classroom to bring the lecture from that classroom into focus. For



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example, the user 602 can enter the classroom C to bring the history lecture into focus. This will cause the other lectures to fade out and/or dim. If the user 602 moves to position 2, she will affect the sound she perceives by changing her location relative to the different sound sources. For example, at position 2, the user 602 will be closer to the classroom E and farther away from the classrooms A and B than she was at position 1. Thus, by moving to position 2, the user 602 will bring the lecture from classroom E into focus, and will cause the lectures from classrooms A and B to fade out and/or dim. If interested in the poetry lecture, the user 602 can then enter the classroom E to listen to the poetry lecture. On the other hand, if the user 602 moves to position 3, she will bring the lecture from classroom F into focus and cause the other lectures to fade out and/or dim."), 11:23-14:53 (describing additional details of system 100 shown in Fig. 1 according to the example method embodiment of Fig. 7), 12:53-58 ("The system 100 can also arrange, order, and/or organize the sound spaces in the three-dimensional sound space according to a setting, a preference, a rule, a similarity, a relevance, a criteria, a ranking, a rating, an age, a user input, a history, a context, a topic, a level of detail and/or granularity, etc."), Figs. 3, 6-7

- **Smyth** at 8:34-60 ("The head tracked PRIR filtering, or convolution, processing 123 indicated in FIG. 1 is illustrated in greater detail in FIG. 2. A digitized audio signal 41 is input to Ch 1 and applied to two convolvers 34. One convolver filters the input signal with the left-ear interpolated PRIR 15 a and the other convolver filters the same signal with the right-ear interpolated PRIR. The output of each convolver is applied to a variable path length buffer 17 that creates an inter-aural differential delay between the left-ear and right-ear filtered signals. Both the PRIR interpolation 15 a and the variable delay buffer 17 are adjusted according to the head orientation 10 fed back from the head tracker 81 in order to affect the virtual soundstage de-rotation. The processes described for Ch1 41 are separately implemented for all other input signals. However, all the left-ear signals, and all the right-ear signals are summed 5 separately prior to their output to the headphones.")
- **Srinivasan** at 10:24-46 ("The concept as described herein is to enable spatial audio signal processing to be performed on an audio signal associated with the object in such a manner that the audio signal appears to come from the approximate position of the object. This may be implemented for example by applying a suitable head related transfer function (HRTF) to an audio signal in the audio pipeline to produce a spatial output before being passed to the sound card and output. In some embodiments the spatial audio signal processing may be applied to the audio signal associated with an object when the object is outside the visible shared scene only. In the following examples the relative position and/or orientation between the user (or listener) and the object (or audio source) may be approximated or substantially defined by the relative position and/or orientation between the user device worn by the user and the object. It is understood that the relative position and/or orientation between the user (or listener) and the object (or audio source) may furthermore in some embodiments be determined as the relative position and/or orientation between the user device worn by the user and the object, and a determined position and/or orientation error or offset (which reflects the difference between the user device and the user's 'center of hearing')."")



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- **Tsingos 989** at 6:63-7:25 ("FIG. 2A is a block diagram of an authoring tool used in an object-based headphone rendering system, under an embodiment. As shown in FIG. 2A, input audio 202 from an audio source (e.g., live source, recording, etc.) is input to a digital audio workstation (DAW) 204 for processing by a sound engineer. The input audio 201 is typically in digital form, and if analog audio is used, an A/D (analog-to-digital) conversion step (not shown) is required. This audio typically comprises object and channel-based content, such as may be used in an adaptive audio system (e.g., Dolby Atmos), and often includes several different types of content. The input audio may be segmented through an (optional) audio segmentation pre-process, 204 that separates (or segments) the audio based on its content type so that different types of audio may be rendered differently. For example, dialog may be rendered differently than transient signals or ambient signals. The DAW 204 may be implemented as a workstation for editing and processing the segmented or unsegmented digital audio 202, and may include a mixing console, control surface, audio converter, data storage and other appropriate elements. In an embodiment, DAW is a processing platform that runs digital audio software that provides comprehensive editing functionality as well as an interface for one or more plug-in programs, such as a panner plug-in, among other functions, such as equalizers, synthesizers, effects, and so on. The panner plug-in shown in DAW 204 performs a panning function configured to distribute each object signal to specific speaker pairs or locations in 2D/3D space in a manner that conveys the desired position of each respective object signal to the listener."), Fig. 2A.

- **Wan** at 2 ("We propose extending this idea to a larger space, which we call the movable 3D audio space. Many sound items are placed in a large virtual 3D audio space. The items are constantly streaming audio content. Instead of selecting a particular item, a user chooses to move (using hand or head gestures, or device movements) to different locations in the virtual space, allowing her to consume multiple sound streams at once."), 6 ("In addition to POI search, a user can move around virtually in 3D audio space, listening for POIs streaming audio information (and maybe even user-generated content). This allows for some spatial awareness (e.g. relative distances between POIs) to be recovered, even in an eyes-free setting. For example, using simple hand or head gestures, a driver can move in 3D audio space corresponding to the vicinity near her real physical location, listening to user-generated reviews on POIs."), 7 ("An item in a 3D space can be generalized to any entity that has interaction. An item might be as simple as a YouTube video stream, or as complex as a group of users playing a virtual board game. Items are movable and their trajectories can depend on each other.")

- **Gorzel** at 1:56-67 ("One embodiment of the present disclosure relates to a method for providing three-dimensional spatial audio to a user, the method comprising: encoding audio signals input from an audio source in a virtual loudspeaker environment into a sound field format, thereby generating sound field data; dynamically rotating the sound field around the user based on collected movement data associated with movement of the user; processing the encoded audio signals with one or more dynamic audio filters; decoding the sound field data into a pair of binaural spatial channels; and providing the pair of binaural spatial channels to a headphone device of the user."), 6:18-29 ("In FIG. 2, M denotes the number of active sources being rendered by the system and method at any one time. In accordance with at least one embodiment, each of blocks 210



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(Distance Effects), 220 (HOA Pan), 225 (HRIR (Head Related Impulse Response) Convolve), 235 (RIR (Room Impulse Response) Convolve), and 245 (Downmix) represents a processing step in the system 200, while blocks 230 (Anechoic Directional IRs) and 240 (Reverberant Environment IRs) denote dynamic impulse responses, which may be pre-recorded, and which act as further inputs to the system 200. The system 200 is configured to generate a two channel binaural output (250).”), Fig. 6.

- **Zhou** at 1048 (“In our experiments, the final augmented virtual image was viewed through a Daeyang Cy-Visor DH-4400VP HMD, which presented the same 640 X 480 pixel image to both eyes … To synchronize with the update of the visual scene, we updated the position of the virtual sound sources 25 times per second. The headphone of the HMD plays back the 3D sound generated by the computer. In this way, we provide an AR environment which is both visually and audibly augmented.”)

### 2. Wearable devices with a display

Wearable devices with a display for showing extended-reality environments were well known to a POSA at and before the purported priority dates of the Asserted Claims. Such devices took a variety of physical forms, including but not limited to helmets, headsets, goggles, and head-mounted displays. It was also known that a display could provide a user with visual images, either of a virtual environment (displaying virtual objects or images) or an augmented environment (displaying a combination of the user’s physical environment and virtual objects or images). Illustrative examples of wearable devices with such displays are disclosed in at least the following:

- **Billinghurst 1998** at 5-6 (“The display is a pair of Virtual i-O iglasses! converted into a monoscopic display by the removal of the left eyepiece. The Virtual i-O head mounted display can either be used in see-through or occluded mode, has a resolution of 262 by 230 pixels and a 26-degree field of view. The iglasses! also have a sourceless two-axis inclinometer and a magnetometer used as a three degree of freedom orientation tracker.”)
- **Ballas 439** at 3:54-4:10 (“A head tracking system 104 is mounted on a frame to which speakers 110 are attached close to the temple of a user’s head. The frame is mounted on the user’s head and moves as the head moves. Any conventional means for attaching the speakers to the frame may be used, such as for example, using fasteners, adhesive tape, adhesives, or the like. The head tracking system 104 measures the location and orientation of a user’s head and provides the measured information to the computer system 102 which processes the audio signals using a head related transfer function (HRTF) filter 106 thus producing spatialized audio. The spatialized audio signals are amplified in an amplifier 108 and fed to speakers 110. The amplified signals are binaural in nature … The speakers 110 are mounted, for example, to an eyeglass frame



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or appropriately mounted to the inside of a helmet as shown in FIGS. 3 and 4. The speakers may also be mounted on a virtual reality head mounted visual display system. A miniature amphitheater-shell may be added to the mounting frame in order to increase the efficiency of the speakers."), Figs. 3 and 4.

- **Ballas 123** at 5:4-59 ("In apparatus 500, as one exemplary embodiment illustrated in FIGS. 5 and 6, the headpiece is a headband 502, the speakers are speakers 504 and 506 and the input system is wire 508. Other non-limiting examples of a headpiece in accordance with the present invention include a hat, helmet, or any other article that can position the speakers to augment the sound such that the user's perceived front-to-back reversals are reduced. Further, other non-limiting examples of a number, size and shape of speakers in accordance with the present invention include those that can reproduce the sound to the user based on the spatially filtered audio signals from the HRTF. Further, the speakers may be water retardant so as to resist corruption by rain or sweat. FIG. 7 illustrates an embodiment of a headband in accordance with the present invention. As depicted in the figure, headband 700 includes a wearable portion 702 and an attachment strip 710. Attachment strip 710 enables speakers 704 and 706 to be attached thereto via an attachment portion, e.g., item 708 as depicted on speaker 706. Attachment strip 710 and attachment portion 708 may be a hook and loop system, such as provided by Velcro®. Accordingly, the positions of speakers 704 and 706 may be changed to minimize the front-to-back reversals. Other attachment mechanisms, which enable speakers to be disposed with the headpiece so as to be positioned to augment the sound such that the perceived front-to-back reversals in a maintained virtual location of the source of the sound are reduced, may be used in accordance with the present invention. Such attachment mechanisms may be permanent, such as by an adhesive, wire, thread, etc., or detachable, such as with a clip or button. FIG. 8 illustrates another embodiment of a headpiece in accordance with the present invention. As depicted in the figure, headband 800 includes a wearable portion 802, and a plurality of attachment areas 804. Attachment areas 804 enables speakers 704 and 706 to be attached thereto via attachment portion 708. Attachment areas 804 and attachment portion 708 may be a hook and loop system, such as provided by Velcro®. Accordingly, the positions of speakers 704 and 706 may be changed to minimize the front-to-back reversals. The number of attachment areas 804 is not limited. For example, a single set of attachment areas 804 may be used, wherein speakers 704 and 708 may be positioned in one respective pair of locations. Alternatively, a plurality of attachment areas may be used, wherein speakers 704 and 708 in addition to other speakers may be positioned thereby minimizing the front-to-back reversals for different users. FIG. 9 illustrates another embodiment of a headpiece in accordance with the present invention, wherein the headband 502 of FIG. 5 has been reversed such that speakers 504 and 506 are disposed against the head of the user. In the reversed position, speakers 504 and 506 generate acoustic signals that are conducted to the auditor senses through bone conduction in the skull, which is a quieter method of delivering the audio signals to the listener."), Figs. 5-9.
- **Flaks 968** at 4:10-13 ("To the listener 8, the sound in the 3D audio signal may appear to be originating from some virtual sound source 29. As one example, the virtual sound source 29 a could be an object being displayed on the display 196."), 9:4-10 ("FIG. 5A



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is a flowchart of one embodiment of a process 500 of determining components for a 3D audio signal. Process 500 is one embodiment of step 306 of process 300. In step 502, the location of a virtual sound source 29 is determined. For example, if a user is interacting with a virtual world depicted on a display 196, then the virtual sound source 29 could be some object being displayed in that virtual world.")

- **Jarvinen** at 15:25-31 ("In an example embodiment, a user may be utilizing a multimedia device such as, for example, apparatus 50 or communication device 90 which may be playing spatial audio output from one or more speakers (e.g. speakers 79, speakers 99 (e.g., headphones, loudspeakers, etc.) while the user wishes to manipulate characteristics of the audio objects in order to improve the listening experience.")
- **Pedersen** at 1:24-31 ("The hearing device may be a headset, a headphone, an earphone, an ear defender, an earmuff, etc., e.g. of the following types: Ear-Hook, In-Ear, On-Ear, Over-the-Ear, Behind-the-Neck, Helmet, Headguard, etc. The hearing device may be a binaural hearing aid. The hearing aids of the binaural hearing aid may be of the types BTE, RIE, ITE, ITC, CIC, etc.")
- **Etter 419** at [0056] ("FIG. 9 shows an illustrative environment for providing binaural audio-visual rendering of a sound source in a video teleconferencing application using a video display screen and a 360 degree or partial angle video camera in the subject conference room, in accordance with a fifth illustrative embodiment of the present invention. The figure shows two rooms—conference room 901 and remote room 902. Remote room 902 contains remote participant 912 who is viewing the activity (e.g., a set of conference participants) in conference room 901 using video display screen 911 and listening to the activity (e.g., one or more speaking conference participants) in conference room 901 using a headset comprising right speaker 909 and left speaker 910. The headset also advantageously comprises head tracker 908 for determining the positioning of the head of remote participant 912."), Fig. 9.
- **Boustead** at 2:52-56 ("The spatialized audio signal may e.g. be a binaural audio signal which is rendered on headphones or loudspeakers at the terminal of the listener. Alternatively or in addition, the spatialized audio signal may be a multi-channel (surround sound) signal, e.g. a 5.1 or a 7.1 multi-channel signal."), 8:26-36 ("It should be noted that the upstream audio signal 123 of a terminal 120 may also be referred to as a talker audio signal 123, because it comprises the audio signal which is generated by the conference participant that is talking at the terminal 120, e.g. talking into a microphone of the terminal 120. In a similar manner, the set of downstream audio signals 124 which is sent to the terminal 120 may be referred to as a set of auditor audio signals 124, because the set 124 comprises the plurality of audio signals which the participant at the terminal 120 listens to, e.g. using headphones or loudspeakers.")
- **Chou** at 5:32-44 ("Referring again to FIG. 1, the sensing device outputs the spatialized audio representation to the standalone stereo listening device 120. The left side and right side sound reproduction elements 124 and 126 of the listening device render the spatialized audio representation. A spatialized audio sound field which includes the virtual sound sources emanates from the left side and right side sound reproduction elements, thus providing the visually impaired person with a spatial cue for each



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different object and passageway in his physical environment. The visually impaired person can use his auditory system to spatially interpret the sound field and thus auditorily determine the spatial geometry of his current physical environment."), Fig. 1, 2.

- **Hammershoi** at [0031]-[0032] ("The RF transmitter may be positioned in connection with the earphone, and/or the RF transmitter is arranged for position in an ear canal of the listener. Preferably, the earphone includes first and second separate earphone parts arranged for position in respective ears of the listener. The first and second earphone parts may be wirelessly interconnected so as to allow wireless transfer of audio data between the first and second earphone parts. The RF transmitter may be included in one of the first and second earphone parts. The RF transmitter may be included in the first earphone part, and wherein a second RF transmitter arranged to transmit a third wireless RF signal, is included in the second earphone part.")
- **Curry** at 9:9-27 ("FIG. 3 shows a schematic of a spatial sound conference system implemented using a spatial sound conference bridge across ISDN facilities. A teleconference using this system links at least two participant stations. Each participant station 310 has right and left spatially disposed loudspeakers 303, 305 and a microphone 307. The right and left loudspeakers may be a stereo headset or loudspeakers for positioning close to the ears of a conference participant. A monaural audio signal from each participant station is picked up by microphone 307 and transmitted to a computer processor 320. Preferably, this processor is unobtrusively integrated into the participant station. This processor includes terminal adapter 328 which converts the monaural analog signal to a digital signal and compression A unit 324 for compressing the digital microphone signal. Conventional compression algorithms, such as ISO MPEG Layer II or III, may be used. Alternatively, compression may be omitted if enough bandwidth is available to transmit the uncompressed signal to the digital network."), Fig. 3.
- **Haddick 248** at [001179] ("FIG. 156 is an illustration of a head mounted display device 15600 with see-through capabilities. The head mounted display device 15600 includes see-through displays 15602, one or more cameras 15604 and electronics 15608, wherein the electronics 15608 can include one or more of the following: a processor, a battery, a global positioning sensor (GPS), a direction sensor, data storage, a wireless communication system and a user interface.")
- **Bradski 253** at [0214] ("As shown in FIG. 4A, a user 60 of a head-mounted augmented reality system ("AR system") is depicted wearing a frame 64 structure coupled to a display system 62 positioned in front of the eyes of the user. A speaker 66 is coupled to the frame 64 in the depicted configuration and positioned adjacent the ear canal of the user 60 (in one embodiment, another speaker, not shown, is positioned adjacent the other ear canal of the user to provide for stereo/shapeable sound control). The display 62 is operatively coupled 68, such as by a wired lead or wireless connectivity, to a local processing and data module 70 which may be mounted in a variety of configurations, such as fixedly attached to the frame 64, fixedly attached to a helmet or hat 80 as shown in the embodiment of FIG. 4B, embedded in headphones, removably attached to the torso 82 of the user 60 in a configuration (e.g., placed in a backpack (not shown)) as



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shown in the embodiment of FIG. 4C, or removably attached to the hip 84 of the user 60 in a belt-coupling style configuration as shown in the embodiment of FIG. 4D.")

- **Stafford 805** at 3:6-27 ("FIG. 1 illustrates a user interacting with a plurality of devices, including a Head Mounted Device (HMD), according to one embodiment. User 114 is wearing HMD 102, which includes a display 110 that renders images near the eyes of the user. In one embodiment, the images are rendered in 3D. Further, although embodiments presented herein are described with reference to a display on the HMD 102, other embodiments may use other view rendering methods, such as projecting an image on the retina of the user. In one embodiment, computing device 106 executes a game that is displayed on the HMD 102. Therefore, computing device 106 cooperates with HMD 102 to display images for playing the game. The processing of game operations may be done on the computing device 106, on the HMD 102, or in both computing device 106 and HMD 102. In another embodiment, the processing of game operations is performed by a networked game server 124, or a cluster of remote game servers (not shown), which cooperate with computing device 106 and/or HMD 102 to display images for playing the game. In yet another embodiment, the HMD 102 cooperates with game server 124 for playing the game.")
- **Balachandreswaran** at [0118]-[0119] ("The processor may comprise an image generator to generate 2D or 3D graphics of objects or characters. It will be appreciated that image generation incurs processing time, potentially leading to the user perceiving lag while viewing the AR rendered physical environment. To mitigate such lag, the processor buffers the data from the at least one camera and rendering the buffered image prior to causing the display system to display the AR rendered physical environment to the user. The image generator preferably operates at a high frequency update rate to reduce the latency apparent to the user. The image generator may comprise any suitable engine, such as, for example, the Unity game engine or the Unreal game engine, to receive an image feed of the physical environment from the imaging system and to generate AR and/or VR objects for the image feed ….")
- **Srinivasan** at 6:9-30 ("The user device 102 in the form of the headset or head mounted device may also comprise at least one camera configured to capture the field of view of the user wearing the headset. For example the headset shown in FIG. 3 comprises stereo cameras 318L and 318R configured to capture an approximate view (or field of view) from the user's left and right eyes respectfully. In some embodiments one camera may be configured to capture a suitable video image and a further camera or range sensing sensor configured to capture or determine the distance from the user to objects in the environment of the user. Similarly the user device 102 in the form of the headset may comprise multiple microphones mounted on the frame 306 of the headset. The example shown in FIG. 3 shows a left microphone 322L and a right microphone 322R located at the 'front' ends of the supporting extensions or arms 306 and 308 respectively. The supporting extensions or arms 306 and 308 may furthermore comprise 'left' and 'right' channel speakers, earpiece or other audio output transducers. For example the headset shown in FIG. 3 comprises a pair of bone conduction audio transducers 320L and 320R functioning as left and right audio channel output speakers.")



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- **Miller 466** at 2:42-3:6 ("The headware of the present invention can include any suitable head-mounted device or apparatus or face-wearable device or apparatus that can specifically include any suitable eyewear such as glasses or goggles. The headwear can include any suitable display such as a head-mounted display. In one embodiment, the headware can be a pair of glasses 31, such as illustrated in FIGS. 1 and 2. The glasses 31 can include a frame 32 made from any suitable material such as plastic or metal, including any suitable shape memory alloy. The frame 32 can have a front piece 33 that can include a first or left lens, display or optical element holder 36 and a second or right lens, display or optical element holder 37 connected by a bridge 38. The front piece 33 additionally includes a left end portion 41 and a right end portion 42. A first or left optical element 43 and a second or right optical element 44 can be provided within respective left and right optical element holders 36, 37. Each of the optical elements 43, 44 can be a lens, a display, a display assembly or a combination of the foregoing. Any of the display assemblies disclosed herein can be provided in glasses 31. When the optical elements 43, 44 include a display, they can each be referred to as near ocular digital displays and can show immersive volumetric three-dimensional graphics, stereo three-dimensional graphics or two-dimensional graphics and can include a liquid crystal display (LCD), an organic light-emitting diode (OLED) display, any other light-emitting diode (LED) display or a laser display. Each of the optical elements 43, 44 includes an inner surface 45 that faces the user and is thus viewable by an eye of the user when the glasses 31 are mounted on the head of the user. When the optical elements 43, 44 include a display, the inner surface 45 is a display surface."), Figs. 1-2.
- **Toshikazu** at [0002] ("Apparatuses (called mixed reality apparatuses) applying a mixed reality (MR) technique, which combines the real world with a virtual world in a natural way without giving sense of oddness, have increasingly been proposed. These mixed reality apparatuses synthesize an image of a virtual world rendered by computer graphics (CG) with the real world sensed by an image sensing apparatus, e.g., a camera, and display the synthesized image on a display device, e.g., a head-mounted display (HMD), thereby exhibiting mixed reality to a user.")
- **Latta** at [0056]-[0058] ("See-through display device 102 also includes a virtual reality engine 604. The virtual reality engine 604 may be configured to cause the see-through display to visually present a virtual object in the form of a virtual arena, one or more avatars, or other virtual objects. The virtual objects can simulate the appearance of real world objects. To a user viewing the physical space through the see-through display, the virtual objects appear to be integrated with the physical space. For example, the virtual objects and/or other images displayed via the see through display may be positioned relative to the eyes of a user such that the displayed virtual objects and/or images appear, to the user, to occupy particular locations within the physical space. In this way, the user is able to view objects that are not actually present in the physical space. Virtual reality engine may include software, hardware, firmware, or any combination thereof … See-through display device 102 may also include one or more features that allow the see-through display device to be worn on the head of a user. In the illustrated example, see-through display device 102 takes the form of eye glasses and includes a nose rest 616 and ear rests 618 a and 618 b. In other embodiments, a



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head-mounted display may include a hat or helmet with an in-front-of-the-face see-through visor. Furthermore, while described in the context of a head-mounted see-through display, the concepts described herein may be applied to see-through displays that are not head mounted (e.g., a windshield) and to displays that are not see-through (e.g., an opaque display that renders real objects observed by a camera with virtual objects not within the camera's field of view).")

- **Katz 031** at 3:41-59 ("As shown in FIG. 1, the VR headset 105 includes an electronic display 115, at least two cameras 120, one or more sensors 125, and an inertial measurement unit (IMU) 130. The electronic display 115 displays images to the user in accordance with data received from the VR console 110. In various embodiments, the electronic display 115 may comprise a single electronic display or multiple electronic displays (e.g., a display for each eye of a user). In some embodiments, the media provided to the electronic display 115 for presentation to the user is pre-distorted to aid in correction of one or more types of optical errors. Additionally, the optical components may increase a field of view of the displayed media through magnification or through another suitable method. For example, the field of view of the displayed media is such that the displayed media is presented using a portion of the user's field of view (e.g., 110 degrees diagonal), or is displayed such that the displayed media is presented using all of the user's field of view (e.g., 180 degrees diagonal).")
- **Ermilov** at [0167] ("… For instance, in another implementation, a headset can incorporate any of the above-identified features (including the input mechanisms 608) together with a head-mounted display (HMD) device of any type, e.g., as physically implemented as eyewear (e.g., goggles), a helmet, etc. The system 102 may display any type of information using the head-mounted display device. For example, the system 102 may display any of the menus and other information described in the next section (Section C) via the head-mounted display device, or some subset thereof. In another case, the system 102 may display computer-generated information that is mixed with information associated with the real world with which the user interacts, to thereby provide an augmented reality experience. For example, the system 102 can display descriptive tags in positional proximity to associated objects and events within the field of vision of the user. In another case, the system 102 can display directional prompts which assist the user in moving in a recommended direction, and so on. Moreover, the system 102 can modify the type of information that is displayed to accommodate any visual impairments that may affect a particular user, e.g., by displaying simplified and enlarged information for users with impairments in sight.")
- **Zhou** at 1048 ("In our experiments, the final augmented virtual image was viewed through a Daeyang Cy-Visor DH-4400VP HMD, which presented the same 640 X 480 pixel image to both eyes … To synchronize with the update of the visual scene, we updated the position of the virtual sound sources 25 times per second. The headphone of the HMD plays back the 3D sound generated by the computer. In this way, we provide an AR environment which is both visually and audibly augmented."), Figs. 1, 3
- **Jin** at 308-09 ("Using a head-tracker and head-mounted display, the user is placed at the scene of the crime and is free to rotate his or her head to choose any point of view



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(Figure 1). Given the relatively narrow field of view provided by contemporary headmounted displays (in this case, a Daeyang i-visor DH-4400VPD 3D), it was deemed necessary to provide a soundtrack that would present the user with spatial cues that could draw his/her attention to any action that may be currently out of view."), 309 ("Although the spatial trajectories were provided for only one viewing angle, the soundscape had to be rendered for all viewing angles to allow for head-tracking. With the headmounted display (HMD), the participant could face any direction, and look up and down to view the panoramic scene and could change their viewing direction at any time. Most head-orientation sensors provide head orientation data in terms of three angles: azimuth, elevation, and roll. Given that it requires approximately 400 azimuth and elevation combinations to cover the sphere with 10 degrees of separation, disregarding directions lower than -45 degrees in elevation, and that there are approximately 19 roll positions in 10 degree steps from -90 degrees to +90 degrees, this implies rendering the soundscape for 400 x 19 or 7600 viewing angles. The sound data corresponding to this number of viewing angles cannot be streamed from a hard disk in real-time with current desktop computers (e.g., it requires a hard disk access rate of 1.25GBytes/second)."), 311 ("Subjective testing of 3DApe was carried out using a headphone (Sennheiser ES2200), head-orientation sensor (Intersense InertiaCube2), and head-mounted display (Daeyang I-Visor 3D).")

- **Kim 417** at Abstract ("The present invention relates to a head mounted display (HMD) for adaptively augmenting virtual audio signals according to an actual audio signal-listening environment, and to a method for providing audio content by using same); [0005] ("A head mounted display (HMD) refers to a variety of digital devices which a user wears like a glass and through which multimedia contents are provided to the user. According to weigh reduction and miniaturization of the digital devices, various wearable computers are being developed, and the above-described HMD is widely being used. Beyond a role of a simple display apparatus, the HMD may provide the use with various conveniences and experiments as combined with augmented reality technologies and N-screen technologies."); [0027]-[0028] ("Referring to FIG. 1, the HMD 100 according to an exemplary embodiment may comprise a processor 110, a display unit 120, an audio output unit 130, a communication unit 140, a sensor unit 150, and a storage unit 160. First, the display unit 120 may be configured to display images in a display screen. The display unit 120 may output a content being played by the processor 110, or output the images based on control commands of the processor 110. Also, according to an exemplary embodiment, the display unit 120 may display the images based on control commands of an external digital device 200 connected to the HMD 100. For example, the display unit 120 may display a content being played by the external digital device 200 connected to the HMD 100. In this instance, the HMD 100 may receive data from the external digital device 200 via the communication unit 140, and output the images based on the received data."); [0087] ("The HMD described in the present disclosure may be changed into or substituted with a variety of devices in accordance with objectives of various exemplary embodiments. For example, the HMD according to an exemplary embodiment may include a variety of devices which a user can wear and which can provide display means, such as Eye Mounted Display (EMD), eyeglasses, eye piece, eye wear, Head Worn Display (HWD), etc. However,



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exemplary embodiments according to the present disclosure are not restricted thereto.").

### 3. Pairing a wearable device with a controller

Methods for pairing a wearable device with a controller were well known to a POSA at and before the purported priority dates of the Asserted Claims. Such controllers and devices took a variety of physical forms, including but not limited to as hand-held devices, mobile devices, and game controllers. It was also known that a wearable devices and controllers could be paired so that the two can communicate through a wired or wireless connection, and for example, share information such as position information derived from sensors within each of the wearable device or the controller. Illustrative examples of such methods are disclosed in at least the following:

- **Billinghurst 1998** at 5 ("A hand held Logitech wireless trackball with three buttons is used as the primary input device."), 167-68 (6DoF "wand type pointing devices" and "joysticks" allow users to "point at or manipulate virtual objects")
- **Schroder** at 8:32-34 ("Playback appliances worn on the body within the scope of the invention include, inter alia, portable CD players, MP3 players and radio receivers. In principle, any appliances which are suitable for reproducing audio information may be used within the scope of the invention.")
- **Flaks 968** at 5:51-54 ("Additionally, the microphone 30 may be used to receive audio signals such as sounds that are provided by a person to control an application that is run by the computing environment 12.")
- **Chou** at 7:62-8:30 ("Referring again to FIG. 2, the standalone environment sensing device 200 can optionally include a set of user controls 232. The visually impaired person can utilize the user controls 232 to customize various aspects of the operation of the sensing device 200 including, but not limited to, the following. The visually impaired person can utilize the user controls to adjust various properties of the virtual sound sources such as the type of sound that emanates from each of the virtual sound sources, the volume of the sound that emanates from each of the virtual sound sources, and the frequency of the sound that emanates from each of the virtual sound sources, among other things. The visually impaired person can also utilize the user controls to choose different modes of operation such as a walk mode, a read mode, an analyze environment mode, and a manipulate object mode, among others. The visually impaired person can also utilize the user controls to adjust the field of view of the object sensor 202. It will be appreciated that the visually impaired person can make these adjustments both on-the-fly (i.e., when he is actively using the sensing device to determine the spatial geometry of his current physical environment) and offline (e.g., when he is not actively using the sensing device to determine the spatial geometry of



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his physical environment). The user controls 232 can be implemented in various ways including, but not limited to, the following. In an exemplary embodiment of the augmented auditory perception technique described herein the user controls 232 include one or more physical control elements (not shown) such as buttons, or sliders, or any combination thereof. The sensing device 200 can optionally also include a location sensor 208 which is also coupled to the first computing device 210 and operates in conjunction therewith to determine the location coordinates (such as latitude and longitude, among others) of the sensing device 200. Various types of devices can be employed for the location sensor 208 such as a global positioning system (GPS) sensor, among others."), Fig. 2

- **Jarvinen** at 17:37-48 ("Referring now to FIG. 5, a flow diagram an example embodiment is provided. In FIG. 5, a device such as, for example, communication device 90 may detect one or more hand gestures to manipulate one or more selected audio objects. The hand gestures may be gestures of a bare hand of a user that may not necessarily be currently holding an apparatus (e.g., apparatus 50). As described above, the communication device 90 may be embodied in a wrist band, bracelet (e.g., a wrist bracelet), game controller, ring, glove, pen, or any other device that is worn by a user or is otherwise attached to the user and which detects hand gestures of the user."), 12:39-42 ("The gesture module 78 may analyze this information to modify an audio object(s) (e.g., an audio signal (e.g., a spatial audio signal)) based in part on the movements of the hand(s), as described more fully below."), Fig. 5.
- **Pedersen** at 5:40-59 ("The hearing device may comprise a data interface for transmission of data from the control device. The data interface may be a wired interface, e.g. a USB interface, or a wireless interface, such as a Bluetooth interface, e.g. a Bluetooth Low Energy interface. The hearing device may comprise an audio interface for reception of an audio signal from the control device or other devices with signal sources capable of transmitting audio signals to the hearing device for provision of the input signals. The audio interface may be a wired interface or a wireless interface. The data interface and the audio interface may be combined into a single interface, e.g. a USB interface, a Bluetooth interface, etc. The hearing device may for example have a Bluetooth Low Energy data interface for exchange of control data between the hearing device and the control device, and a wired audio interface for exchange of audio signals between the hearing device and the control device and other devices with signal sources."), Fig. 1.
- **Boustead** at 13:5-44 ("FIG. 2 illustrates a Graphical User Interface (GUI) 200 of a conference scene which may be provided at the conference server 100 and/or at the terminals 120. If provided at a terminal 120, the GUI 200 may enable a participant to modify the conference scene as perceived at the terminal 120. In an embodiment, the GUI 200 enables a chairperson of an audio conference to place the conference participants within a conference scene. The GUI 200 may indicate the participants 201 of the audio conference. The participants 201 may correspond to the originators of the audio signals comprised within a set of downstream audio signals. As such, the GUI 200 may indicate up to (M-1) participants 201. Furthermore, the GUI 200 may illustrate the conference scene 210. In FIG. 2 a 2D (two-dimensional) conference scene is illustrated, e.g. as a circle. It should be noted that the GUI 200 may be adapted to



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illustrate a 3D (three-dimensional) conference scene, e.g. as a sphere. The listener 211 (i.e. the terminal 120 which receives the terminal specific set of downstream audio signals 124) may be placed by default in the center of the scene 210. The GUI 200 may be configured to allow for a modification of the location of the listener 211. Furthermore, the GUI 200 provides a plurality of talker locations 212 (which are illustrated as empty dots 212 in FIG. 2). The plurality of talker locations 212 may be pre-defined or may be selected by a user of the GUI 200. The talker locations 212 may be assigned to one or more of the conference participants 201. This may be done automatically (e.g. based on the metadata received along with the set of downstream audio signals 124). Alternatively or in addition, the GUI 200 may allow for a user specific assignment (e.g. using a "drag and drop" operation of the indicated participants 201 to the talker locations 212). The assignment of a participant 201 and the talker location 212 may be indicated, e.g. using a pop-up window 213. In addition, the GUI 200 may allow to indicate and/or to modify additional sound locations 214 (which are illustrated as filled dots 214 in FIG. 2). Such sound locations 214 may be used to render sounds other than audio signals (typically voice signals) of the participants, e.g. conference notifications and/or music."), Fig. 2.

- **Bedingfield** at 6:27-51 ("From the decision block 304, the listener may select the mode for modifying individual participants via route B at the block 308. At a selection block 322, the listener may select a setting, such as to place the focus at a block 324, to change a participant's volume at a block 326, or to change a participant's location at a block 328. If the listener selects to place the focus at the block 324, the listener then selects a participant for the focus (the focus object). The focus object's volume may then be amplified above the volume level of the other participants. For example, when multiple participants are speaking during a conference, the listener may desire to place the focus on the participant the listener desires to hear above the other speaking participants. If the listener selects to change the volume at the block 326, the listener may select a participant and adjust the volume, or other aspects of the participants sound such as the aspects adjustable by the block 316. If the listener selects to change the location at the block 328, the listener selects a participant and then selects a new location for the participant within the sound field. The listener may also relocate his position within the sound field at the block 328. After the setting is selected at the selection block 322 and a setting is selected and implemented at the blocks 324, 326 or 328, the method 300 advances to the decision block 318 and then to either the decision block 304 or the block 320 as described above.")

- **Begault 2000** at 170 ("A Virtual Reality Application: NASA's VIEW System The implementation of the Convolvotron 3-D audio device within NASA's VIEW system gives an example of how distributed 3-D audio devices and tone generators are integrated within a dedicated virtual reality application. Wenzel, et al. (1990) created a distributed audio system as part of a virtual environment for providing symbolic acoustic signals that are matched to particular actions in terms of the semantic content of the action taken. The sounds are not only spatialized in 3-D dimensions for conveying situational awareness information but are also interactively manipulated in terms of pitch, loudness and timbre. Figure 5.11 shows the hardware configuration for the auditory display. The reality engine at the time consisted of a Hewlett Packard



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HP900/835 computer. The RS-232 port was used to drive a Digital Equipment DECTALK TM speech synthesizer, a Convolvotron, and two Ensoniq ESQ-M TM tone generators via an RS-232-MIDI converter. In the configuration, the Convolvotron receives data over the RS-232 port regarding the head-tracker orientation and action of a VPL Data Glove TM, and spatializes the output of one of the two synthesizers. A standard audio mixer is used to sum the outputs of the synthesizer, Convolvotron, and speech synthesizer."), 173 ("[A]udio in any virtual reality configuration can provide an important source of feedback. For instance, the VPL Data Glove works by analyzing a combination of detected finger positions and then using the software to match them to sets of predefined gestures (e.g., a peace sign, pointing with the index finger, squeezing hand as a fist)."), Fig. 5.11

- **Cohen 1991 II** at 39 ("With a device like a DataGlove, a user can point and gesticulate using a 3D workspace envelope."), 39 ("Pointing at a source indicates it, as a prelude for selection by grasping"), 57 ("The standard pointing device in a window/icon/menu/pointing device (wimp) system is a mouse. A mouse, trackball (a mouse on its back), or joystick would suffice for positioning objects in 2-space. One can imagine direct control of position (with a mouse, trackball, or DataGlove, say), steering control (with a return-to-center joystick, perhaps), or programmed control (automatic circulation)," "for instance, used joysticks to manipulate crudely spatialized sources. As long as visual tokens for the spatial sound objects are accessible through the workstation, they can be manipulated through the operations described above. For example, a mouse-based system finds analogs to indicating, highlighting, and relocating in pointing, clicking, and dragging. A speaker might be singled out for special attention by clicking her token, which would throw a spotlight on her voice."), 90 ("In a gestural interface (like Handy Sound's), pointing and grasping are natural postures for indicating and securing.").

- **Jerald** at 282 ("hand-tracked devices work well for a virtual hand technique and for pointing"), 299 ("Direct gestures are immediate and structural (Section 1.2.1) in nature and convey spatial information; they can be interpreted and responded to by the system as soon as the gesture starts. Direct manipulation, such as pushing an object, and selection via hand pointing are examples of direct gestures."), 301 ("for some environments, selecting an object might only be performed by pointing"), 303 ("An example is verbally requesting a specific menu to appear, which can be interacted with by speaking or pointing."), 314-315 ("Tracked hand-held controllers are typically 6 DoF devices (known as 'wands' in the VR research community where they have been used for decades) and can also contain functionality offered by non-tracked hand-held controllers. Tracked hand-held controllers are currently the best option for a majority of interactive VR applications. Tracked hand-held controllers are easy to use for many 3D tasks due to their natural, direct mapping to hand motion."), 325 ("Selection patterns include the Hand Selection Pattern, Pointing Pattern, Image-Plane Selection Pattern, and Volume-Based Selection Pattern"), 327 ("The Pointing Pattern is typically better for selection than the Hand Selection Pattern unless realistic interaction is required. This is especially true for selection beyond personal space and when small hand motions are desired. Pointing is faster when speed of remote selection is important [Bowman 1999], but is also often used for precisely selecting close objects, such as



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pointing with the dominant hand to select components on a panel (Section 28.4.1) held in the non-dominant hand."), 328 ("Hand pointing. When hand tracking is available, hand pointing with a ray extending from the hand or finger is the most common method of selection. The user then provides a signal to actually select the item of interest (e.g., a button press or gesture with the other hand)."), 345-49 (describing various controls menus and interfaces)

- **Knappe** at 9:43-67 ("GUI 100 can allow a user to manually partition the sound field. One possible GUI 'look and feel', illustrated in FIGS. 7A and 7B, shows a method of manual partitioning. FIG. 7A shows a GUI screen 110 at the start of a conference call. The presentation sound field is represented in GUI screen 110 by annular half-circle 112. Endpoints B, C, and D are portrayed respectively in blocks 114, 116, and 118 (endpoint D's block 118 is shown smaller than the others because D represents a monophonic sound source). The blocks initially appear to the inside of the half-circle 112, signaling that no sound field mapping is currently being done on any of these sources. FIG. 7B shows GUI screen 110 after manipulation by a listener. The listener has created a presentation sound field sector for each endpoint, e.g., by dragging and dropping blocks 114, 116, and 118 onto half-circle 112. Endpoint B now occupies sector 122, i.e., approximately the leftmost 75 degrees of the sound field. Endpoint C now occupies, sector 124, i.e., the 75 degree sector from about 15 degrees left of center to about 60 degrees right of center. Endpoint D now occupies sector 126, i.e., approximately the rightmost 30 degrees of the sound field. Note that the listener has replaced the generic labels of each endpoint with icons containing the names of the conference participants at each location. The listener can also manipulate the widths of sectors 122, 124, and 126 by moving the sector dividers."), Figs. 7A and 7B
- **Nystrom** at 5:27-45 ("User device 204 may include any of the following devices to which earphones may be attached (e.g., via a headphone jack): a personal computer; a tablet computer; a cellular or mobile telephone; a smart phone; a laptop computer; a personal communications system (PCS) terminal that may combine a cellular telephone with data processing, facsimile, and/or data communications capabilities; a personal digital assistant (PDA) that includes a telephone; a gaming device or console; a peripheral (e.g., wireless headphone); a digital camera; or another type of computational or communication device. Via user device 204, a user may place a telephone call, text message another user, send an email, etc. In addition, user device 204 may receive and store computed HRTFs from HRTF device 206. User device 204 may use the HTRFs to generate signals to drive earphones 110 to provide stereo sounds. In generating the signals, user device 204 may apply intensity panning, to be described below, based on HRTFs stored on user device 204.")
- **Gardner** at 9:47-60 ("The client 200 is under control of a virtual world engine 430, which generates graphics and sound, and receives user-interface commands from the user A via input devices such as a keyboard 433 and mouse 436. These include positional commands that update the position and orientation of the user A in a local world model 440, which is a data structure stored in memory and containing information specifying positions and orientations users in a virtual world. The commands are also sent to the world model server (not shown but described below) via the network 200 where they are forwarded to other clients. The positions of other users


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are received from the world model server and entered into the local world model, which is used to generate the proper graphics and sound (except speech sound from the other users) for the user A.")

- **Li 305** at 14:5-18 ("FIG. 7 illustrates a method for simultaneously generating configurable three-dimensional (3D) sounds using a microphone array system. Three-dimensional (3D) sound comprises 3D surround sound, 3D binaural sound, and 3D stereo sound. 3D sound comprises, for example, music, speech, any audio signal, etc., and is used with or without 3D images, 3D movies, and 3D videos. 3D sound allows a user to experience sound in a 3D space. As used herein, the term "user" refers to a listener of a sound recording, or a person receiving an audio signal on audio media. The 3D sound is represented as a 3D binaural sound when used with a headset or as a 3D surround sound when used with multiple loudspeakers, for example, in a home theater speaker system. The 3D stereo sound is considered as a special case of the 3D sound.")
- **Katz 561** at 2:30-61 ("FIG. 1 is an example of a system environment 100 for tracking movement of a controller 120 according to an embodiment. The system environment 100 includes a user using a headset 105 and the controller 120, and an image tracking system 160. As the user uses the controller 120, the user may move the controller 120 through space in front of the user's body, rotate the controller 120, and rotate the user's body. The movement of the controller 120 as the user performs these motions is captured by imaging devices (e.g., cameras) on the headset 105 and on the image tracking system 160. The imaging device(s) on the headset 105 capture a view of the controller 120 from a headset view 110 showing the controller 120 from the user's perspective, while the imaging devices on the image tracking system 160 capture a view of the controller 120 from a tracking system view 170 showing the controller 120 from the perspective of the image tracking system 160. In this way, views of the controller 120 are captured from multiple different perspectives, and as the image tracking system 160 is typically apart from the user, the views provided of the controller by the headset view 110 and the tracking system view 170 will typically substantially differ in the angle of view to the controller 120, providing different perspectives on the controller 120's location and rotation, such as by providing opposite or orthogonal views of the controller 120. A console (not shown in FIG. 1) receives the captured images from the headset view 110 and the tracking system view 170 and calculates the pose of the controller 120. As used herein, the "pose" of the controller 120 refers to its location and rotational orientation."), Figs. 1, 2-4.
- **Laitinen** at 2:33-3:6 ("The apparatus 2 includes a device 10 and a headset 11. The device 10 may be a hand-held communications device which includes a telephone application, such as a smart phone for example. The device 10 may also comprise other applications including, for example, an Internet browser application, camera application, video recorder application, music player and recorder application, email application, navigation application, gaming application, and/or any other suitable electronic device application. The device 10, in this example embodiment, comprises a housing 12, a display 14, a receiver 16, a transmitter 18, a rechargeable battery 26, and a controller 20. The controller may comprise at least one processor 22, at least one memory 24, and software 28 in the memory 24. However, all of these features are not necessary to implement the features described below. In an alternate example, the



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device 10 may be a home entertainment system, a computer such as used for gaming for example, or any suitable electronic device suitable to reproduce sound for example … The apparatus 10 is connected to a head tracker by a link 15. The link 15 may be wired and/or wireless. The head tracker 13 is configured to track the position of a user's head. In an alternate example, the head tracker 13 may be incorporated into the apparatus 10 and perhaps at least partially incorporated into the headset 11. Information from the head tracker 13 may be used to provide the direction of arrival 56 described below."), Fig. 1

- **Stafford 805** at 4:15-18 ("In one embodiment, the computing device 106 calculates a relative position between the HMD 102 and the game controller 116. The relative position is then used by the game to move a game object in synchronism with the HMD 102.").
- **Lovitt** at [0036] ("User-controlled element 210 may be controlled, for example, via a hand-held game controller (not shown) operated by the first user 206. It will also be appreciated that in other embodiments the user-controlled element 210 may be controlled based on the movement(s) of a human subject imaged by a tracking system 234 that includes an optical sensor system as described above with reference to FIG. 1. In other embodiments, user-controlled element 210 may be controlled via the HMD device 200, or via additional and/or different input devices including, but not limited to, keyboards, mice, microphones for voice recognition, and the like."), Fig. 1
- **Najaf-Zadeh** at 4:8-32 ("HMD 100 further includes one or more sensor(s) 165 that can meter a physical quantity or detect an activation state of the HMD 100 and convert metered or detected information into an electrical signal. For example, sensor 165 may include one or more buttons for touch input, e.g., on the headset or the HMD 100, a camera, a gesture sensor, a gyroscope or gyro sensor, an air pressure sensor, a magnetic sensor or magnetometer, an acceleration sensor or accelerometer, a grip sensor, a proximity sensor, a color sensor 165H (e.g., a Red Green Blue (RGB) sensor), a bio-physical sensor, a temperature/humidity sensor, an illumination sensor 165K, an Ultraviolet (UV) sensor, an Electromyography (EMG) sensor, an Electroencephalogram (EEG) sensor, an Electrocardiogram (ECG) sensor, an IR sensor, an ultrasound sensor, an iris sensor, a fingerprint sensor, etc. The sensor(s) 165 can further include a control circuit for controlling at least one of the sensors included therein. As will be discussed in greater detail below, one or more of these sensor(s) 165 may be used to control audio rendering, determine the orientation and facing direction of the user for 3D content display identification, etc. Any of these sensor(s) 165 may be located within the HMD 100, within a headset configured to hold the HMD 100, or in both the headset and HMD 100, for example, in embodiments where the HMD 100 includes a headset.")
- **Sawyer** at [0033] ("A controller according to aspects of certain embodiments receives and processes detection signals from the HMD and/or external sensors and generates corresponding feedback to the user based on the proximity of Soft Bounds and/or Hard Bounds and/or based on explicit user request for feedback (e.g., an "overlay button")."), [0059] ("First, a user can simply walk around in the real operating space, holding his or her controller and moving it along some or all of the walls/floor/ceiling of the



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operating space. The measurements taken via this process are transmitted to the chaperoning system controller using any appropriate technique, as known to skilled artisans.")

- **Pedrotti** at 2:44-59 ("Another embodiment discloses a system to assist a user in remaining in a selected area of the physical world, the user wearing a head-mounted display (HMD) and holding a handheld controller, comprising: a controller tracker on the handheld controller which provides information regarding a position of the handheld controller; and a processor configured to: receive as an input a definition of a boundary of the selected area; determine the position of the handheld controller in the physical world using information from the controller tracker; generate and output instructions to the HMD to display on the HMD a virtual world; determine from the position of the handheld controller that the handheld controller is within a first preselected distance from the boundary; and generate and output instructions to the HMD to display on the HMD a first visual warning in the virtual world."), 4:25-31 ("[s]ome examples of the real controller device are a joystick, a steering wheel, a touch pad, a gamepad, a pointing device (e.g. mouse), a trackball assembly, a handheld inertial motion unit (IMU), a touch display (e.g. a touch pad or a multi-point touch pad) or other types of controllers, for example, other types of real controllers typically associated with gaming consoles or game applications"), 5:8-24 ("Another such example are light-emitting trackers which can be seen by, and therefore provide position and orientation information to, a camera mounted on the base station or elsewhere. As would be understood by one of ordinary skill in the art in light of the teachings herein, essentially any type of tracker (e.g., magnetic, optical, electrical, sonar, radar, ultrasonic, or any combination thereof ) which can provide information regarding its position (and, in some cases, orientation, if needed or desired) can be used in the present approach. As would be understood by one of ordinary skill in the art in light of the teachings herein, essentially any type of tracker (e.g., magnetic, optical, electrical, sonar, radar, ultrasonic, or any combination thereof) which can provide information regarding its position (and, in some cases, orientation, if needed or desired) can be used in the present approach. Such techniques are all contemplated as being within the described system and method, including techniques which can only provide position information, and not orientation, even though the below discussion generally refers to electromagnetic tracking."), 9:29-52 ("In a conventional video game, for example, a user may use a controller to have a character on a television screen "pick up" a weapon displayed on the screen. Similarly, with the present approach the processor can cause a HMD to display a virtual weapon while the user is in a virtual world. Then, upon the user's extending his or her physical hand( s) in such a way as to cause the corresponding virtual hand(s) to "reach for" the displayed virtual weapon and the user's activating a proper command (e.g., by pressing a button on the controller), the processor can cause the HMD to display the user's virtual hand(s) 214 as "picking up" and holding that virtual weapon. FIG. 8 shows one example of what a user might see in a virtual world after the user has extended the user's physical right hand to cause the virtual right hand to extend toward a virtual sword displayed in the virtual world on the HMD, and then entered the appropriate command to pick up the virtual sword 802. The user's virtual right hand 214 is holding the virtual sword 802, although of course there is no physical sword and the user's physical right hand is instead still holding the



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physical controller. The processor can then display movements of the virtual sword 802 based upon movements of the user's physical right hand as determined from motion of the tracker in the physical controller."), Fig. 8

- **Wan** at 4:29-35 ("The VR controller 136 can, e.g., emit and/or reflect infrared (IR) or any other type(s) of light that can be detected by one or more of the cameras 113 and 114 to help determine positions of, for example, the user's hands."), 4:27-32 ("As will be discussed more thoroughly below, a user 135 can have a VR controller 136. The VR controller 136 can, e.g., emit and/or reflect infrared (IR) or any other type(s) of light that can be detected by one or more of the cameras 113 and 114 to help determine positions of, for example, the user's hands. Likewise, other elements 115 in the VR system 100 can emit and/or reflect IR or other type(s) of light for tracking or other VR purposes.")

#### 4. Tracking the user

Methods for tracking the user, including using the position of a wearable device or a controller as a representation of the user's location, were well known to a POSA at and before the purported priority dates of the Asserted Claims. Such known methods include using a device (e.g., wearable device, controller) equipped with location sensors, depth cameras, image tracking, map making, or constellation sensors. Illustrative examples of such methods are disclosed in at least the following:

- **Billinghurst 1998** at 5-6 ("The display is a pair of Virtual i-O iglasses! converted into a monoscopic display by the removal of the left eyepiece. The Virtual i-O head mounted display can either be used in see-through or occluded mode, has a resolution of 262 by 230 pixels and a 26-degree field of view. The iglasses! also have a sourceless two-axis inclinometer and a magnetometer used as a three degree of freedom orientation tracker."), at 6 ("The wearable user has their head tracked so they can simply turn to face the speakers they are interested in.")
- **Otto 440** at 10:34-44 ("Another optional component is a listener tracking device (LTD) 116, which allows the apparatus to receive information on the location of the listener(s) and to dynamically adapt the spatialization filters in real time. The LTD 116 may be a video tracking system which detects the user's head movements or can be another type of motion sensing system as is known in the art. The LTD 116 generates a listener tracking signal which is input into a filter computation algorithm 118. The adaptation can be achieved either by re-calculating the digital filters in real time or by loading a different set of filters from a pre-computed database.")
- **Schroder** at 6:23-7:4 ("In one exemplary embodiment, the absolute position of the listener is determined using a beacon transmitter, which is arranged stationary in the listening room, and two receivers, which are arranged on the head or on the headphones



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and on the trunk of the listener. The beacon transmitter radiates a beacon signal which is received by the receivers. A control circuit evaluates properties of the beacon signal received by the receivers and uses these to ascertain the relative position of the head in relation to the trunk. The beacon signal used may be radio signals, light signals or ultrasonic signals, or combinations of these. The beacon signals are preferably in modulated form. Evaluatable properties of the beacon signal are, by way of example, the amplitude, the phase, the propagation time or combinations of these. The ascertained position of the head is forwarded to the variable HRT filters as a control variable for adjusting the virtual position of the aural event.")

- **Ballas 439** at 2:41-47 ("A head tracking system also mounted on the frame where speakers are mounted determines the location and orientation of the listener's head and provides the measurements to a computer system for audio signal processing in conjunction with a head related transfer function (HRTF) filter to produce spatialized audio."), 2:54-3:2 ("In its broader aspects, the present invention provides an apparatus for producing spatialized audio, the apparatus comprising at least one pair of speakers positioned near a user's temple for generating spatialized audio signals, whereby the speakers are positioned coaxially with a user's ear regardless of the user's head movement; a tracking system for tracking the user's head orientation and location; a head related transfer function (HRTF) filter for maintaining virtual location of the audio signals thereby allowing the user to change location and head orientation without degradation of the virtual location of audio signals; and a processor for receiving signals from the tracking system and causing the filter to generate spatialized audio, wherein the speakers are positioned to generate frontal positioning cues to augment spatial filtering for virtual frontal sources without degrading spatial filtering for other virtual positions."), 3:54-4:10 ("A head tracking system 104 is mounted on a frame to which speakers 110 are attached close to the temple of a user's head. The frame is mounted on the user's head and moves as the head moves. Any conventional means for attaching the speakers to the frame may be used, such as for example, using fasteners, adhesive tape, adhesives, or the like. The head tracking system 104 measures the location and orientation of a user's head and provides the measured information to the computer system 102 which processes the audio signals using a head related transfer function (HRTF) filter 106 thus producing spatialized audio. The spatialized audio signals are amplified in an amplifier 108 and fed to speakers 110. The amplified signals are binaural in nature … The speakers 110 are mounted, for example, to an eyeglass frame or appropriately mounted to the inside of a helmet as shown in FIGS. 3 and 4. The speakers may also be mounted on a virtual reality head mounted visual display system. A miniature amphitheater-shell may be added to the mounting frame in order to increase the efficiency of the speakers."), Figs. 3 and 4.
- **Flaks 968** at 14:5-7 ("The diagram of FIG. 10 depicts that sensor input may be used for various reasons. Sensor input may be used to calculate the user's position and rotation, as depicted in box 1020."), Fig. 10
- **Pedersen** at 9:25-49 ("The hearing device may include an orientation sensor unit for sensing the orientation of the head of the user, when the user wears the hearing device in its intended operational position on the user's head, and the processor may further be configured to adjust selection of the directional transfer function(s) of the binaural


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filter(s) based at least in part on the sensed orientation of the head of the user. In this way, the at least one sound source will be perceived to remain fixed with relation to user's environment irrespective of the changes in orientation of the user's head subsequent to the selection of the directional transfer function(s) of the binaural filter(s). Thus, if the user turns his or her head 30° to the left, the processor may be configured to select directional transfer function(s) with perceived direction(s) towards the corresponding at least one sound source turned 30° to the right in such a way that the user perceives the at least one sound source to remain in fixed position(s) in the sound environment, i.e. the rate of change of the perceived direction(s) corresponds to the rate of change of the orientation of the head of the user. The orientation of the head of the user may be defined as the orientation of a head coordinate system having a vertical axis and two horizontal axes at the current location of the user with relation to a reference coordinate system that is fixed with relation to the surroundings.")

- **Etter 419** at [0055] ("In accordance with the principles of the present invention, and in accordance with the fourth illustrative embodiment thereof, the head movements of remote participant 812 are tracked with head tracker 808, and the resultant head movement data is transmitted by link 815 from remote room 802 to conference room 801. There, this head movement data is provided to dummy head 803 which properly mimics the head movements of remote participant 812 in accordance with an appropriate angle conversion function f(Δφ) as shown on link 815. (The function 'f' will depend on the location of the dummy head in conference room 801, and will be easily ascertainable by one of ordinary skill in the art. Illustratively, the function 'f' may simply be the identity function, i.e., f(Δφ)=Δφ, or it may simply scale the angle, i.e., f(Δφ)=qΔφ, where q is a fraction.) Moreover, the video captured in conference room 801 by cameras 806 and 807 is transmitted by link 813 back to remote room 802 for display on video display screen 811, and the binaural (L/R) audio captured by microphones 804 and 805 is transmitted by link 814 back to remote room 802 for use by speakers 809 and 810. Video display screen 811 may display the received video in either 2D or 3D. However, in accordance with the principles of the present invention, and in accordance with the fourth illustrative embodiment thereof, the binaural audio played by speakers 809 and 810 will be advantageously generated in accordance with the principles of the present invention based, inter alia, on the location of the human speaker on video display screen 811, as well as on the physical location of remote participant 812 in remote room 802 (i.e., on the location of remote participant 812 relative to video display screen 811)."), Figs. 8 and 9.
- **Chou** at 6:12-45 ("Referring again to FIG. 2, the object sensor 202 is coupled to the first computing device 210 and they generally operate together to determine the spatial geometry of the visually impaired person's current physical environment. More particularly and as will be described in more detail hereafter, the object sensor 202 and the first computing device 210 operate together to generate a spatial map of the visually impaired person's current physical environment, where the spatial map identifies the current location of objects and passageways in the environment. The first spatial orientation sensor 204 is also coupled to the first computing device 210 and they operate together to determine the current spatial orientation of the standalone environment sensing device 200. The second spatial orientation sensor 226 is coupled



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to the second computing device 222 and they operate together to determine the current spatial orientation of the standalone stereo listening device 206, which equates to the current spatial orientation of the visually impaired person's head since the listening device is worn thereon. The second computing device 222 outputs information 228 to the sensing device 200 via the data output interface 224, where this information includes the current spatial orientation of the visually impaired person's head. The first computing device 210 receives this information 228 via the data input interface 214. The first computing device 210 compares the current spatial orientation of the sensing device 200 to the current spatial orientation of the visually impaired person's head in order to determine the relative current pose between the sensing device and the visually impaired person's head. As will be described in more detail hereafter, in certain embodiments of the augmented auditory perception technique described herein the current distance between the sensing device 200 and the listening device 206 can optionally also be determined using the first and second spatial orientation sensors 204 and 226."), 7:4-42 ("Referring again to FIG. 2, the first and second spatial orientation sensors 204 and 226 can be implemented in various ways including, but not limited to, the following. In one embodiment of the augmented auditory perception technique described herein both the first and second spatial orientation sensors are an electronic gyroscope (such as a conventional MEMS (micro-electro-mechanical systems) gyroscope, among others). In another embodiment of the augmented auditory perception technique both the first and second spatial orientation sensors are a magnetometer. In yet another embodiment of the augmented auditory perception technique both the first and second spatial orientation sensors are an accelerometer combined with a solid state compass. In yet another embodiment of the augmented auditory perception technique both the first and second spatial orientation sensors are a visible light camera. In yet another embodiment of the augmented auditory perception technique the first spatial orientation sensor is an electromagnetic field generator and the second spatial orientation sensor is an electromagnetic field sensor. In yet another embodiment of the augmented auditory perception technique the first spatial orientation sensor is an electromagnetic field sensor and the second spatial orientation sensor is an electromagnetic field generator. In each of these embodiments the first spatial orientation sensor can optionally also include a first distance measurement device (not shown) and the second spatial orientation sensor can optionally also include a second distance measurement device (not shown) that is matched to the first distance measurement device. The first and second distance measurement devices are used together to determine the current distance between the standalone environment sensing device 200 and the standalone listening device 206 (which equates to the current distance between the sensing device and the visually impaired person's head). It will be appreciated that various types of distance measurement devices can be employed. By way of example, but not limitation, the first distance measurement device can be an ultrasound receiver and the second distance measurement device can be an ultrasound transmitter that is matched to the ultrasound receiver, or vice versa."), Fig. 2

- **Hammershoi** at [0029]-[0030] ("The position tracking means may include position sensing means arranged to sense the first position, and wherein the RF transmitter is arranged to include data indicating the first position in the second wireless RF signal. The position tracking means may further include a second sensing means arranged to



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senses the second position, and wherein the RF transmitter is arranged to further include data indicating the second position in the second wireless RF signal. The RF transmitter may be arranged for location at the first position, and wherein the position tracking means further includes a second RF receiver arranged to receive the second wireless RF signal and determine the first position by detecting a location from which the second wireless RF signal is transmitted. A second RF transmitter may be arranged for transmitting a third wireless RF signal, the second RF transmitter being arranged for location at the second position, and wherein the second RF receiver is further arranged to receive the third wireless RF signal and determine the second position by detecting a location from which the third wireless RF signal is transmitted. The second RF receiver may include an array of antennas and a signal processing unit.")

- **Bedingfield** at 6:54-58 ("A sensor may be provided to allow a user to control the orientation, focus, or other aspects of the rendering of the sound field, such as by sensing the movements of the listener and then changing the sound field or audio output according to the sensor-collected information."), 13:48-57 ("If the listener moves to a second position (such as by turning his head), as detected by the receiver 1310 from movement (e.g., rotation) of the wearable speakers 1312, then the listener 104 may be orientated in a second position within the sound field 122. In other embodiments, the receiver 1310 may detect the movement or orientation of other wearable devices. The movement or orientation may be detected utilizing motion detectors, gravity based sensors, or other movement detection devices, including physical, electronic, and image based detection devices.")
- **Begault 2000** at 133 ("The magnetic tracker's sensor is usually attached to the body; those relevant to 3-D sound are placed as close to the top of the head as possible. The sensor measures the low-frequency magnetic field generated by the source, which is located outside the body a few feet away and can be used to symbolize the position of the virtual sound source. Positional data about the user's position in relationship to the source can then be obtained in terms of pitch, yaw, and roll, and x, y, and z (see Figure 4.37). The 3-D audio subsystem then can compensate for the relative position of source and sensor to give the illusion of a sound that remains fixed in space independent of head movement."), Fig. 4.17
- **Haddick 248** at [00650] ("In embodiments, the user may be able to control their view perspective relative to a 3D projected image, such as a 3D projected image associated with the external environment, a 3D projected image that has been stored and retrieved, a 3D displayed movie (such as downloaded for viewing), and the like. For instance, and referring again to Fig. 15C, the user may be able to change the view perspective of the 3D displayed image 1512C, such as by turning their head, and where the live external environment and the 3D displayed image stay together even as the user turns their head, moves their position, and the like. In this way, the eyepiece may be able to provide an augmented reality by overlaying information onto the user's viewed external environment, such as the overlaid 3D displayed map 1512C, the location information 1514C, and the like, where the displayed map, information, and the like, may change as the user's view changes. In another instance, with 3D movies or 3D converted movies, the perspective of the viewer may be changed to put the viewer 'into' the movie environment with some control of the viewing perspective, where the user may be able


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to move their head around and have the view change in correspondence to the changed head position, where the user may be able to 'walk into' the image when they physically walk forward, have the perspective change as the user moves the gazing view of their eyes, and the like. In addition, additional image information may be provided, such as at the sides of the user's view that could be accessed by turning the head.")

- **Curry** at 5:39-53 ("The remote participant station 199 may also include a head-tracking sensor 119. A head-tracking sensor can detect movements of a remote participant such as the pan and tilt of a remote participant's head. A sensor, such as one manufactured by Polhemus Navigation Sciences Division of McDonnell Douglas of Colchester, Vt., mounted on a headband can sense the movement of a head in the pan, tilt, and rotate axes. This movement information can be processed using convertor 163 and transmitted across ISDN facilities 150 using the 16 kbs D channel along with call signaling information. At the conference room station 100, the D channel may be connected to convertor 143 and then to a pan/tilt motorized unit 109 for controlling the dummy head 101. Thus, the dummy head may track the movements of a remote participant's head. Other servo arrangements may be utilized to replicate a remote participant's head orientation using the dummy head. This head-tracking feature greatly increases the spatialization ability of a remote participant. By directing the movement of the dummy head to face a particular speaker in conference room station 100, the remote participant can isolate and understand the speech of that participant, even if that participant is speaking very softly. Movement of the right and left microphones also provides additional spatialization cues to the remote listener to aid in locating and understanding participants within the conference room station.")

- **Gardner** at 8:16-50 ("As shown in FIG. 3B, the spatial locations of users in E's conference depend on the relative virtual locations of E, F, and H, and the virtual orientation of E. The generated spatial locations will, therefore, change as E changes his orientation or moves about, and will also change if users F and H move. Similarly, the reverberation characteristics of E's conference will depend on the characteristics of the enclosing virtual room, if any. It is also possible to model different reverberation effects if, for example, user H is in a virtual room adjoining E's room, and which has reverberant characteristics different from E's room. In this case, the sound of H's voice can be rendered with a different reverberation. Additional environmental cues that may be modeled include object occlusion, source directivity, and the Doppler motion effect. Object occlusion refers to the modification of sound caused by an occluding object between the sound and the listener. For example, with continued reference to FIGS. 3A and 3B, if user F is behind a wall but still audible, the sound of her voice can be altered to model the occluding effect of the wall. Source directivity refers to the fact that a source may project sound non-uniformly. For example, a human talker projects low frequencies uniformly in all directions, but high frequencies are transmitted primarily in the direction the talker is facing. The Doppler motion effect is a pitch change of the sound caused by the relative motion of the sound and the listener. This effect is audible only if users are rapidly moving in the virtual world, which might occur in game play if, for example, one of the users is riding a virtual vehicle. The positions and orientation of users in the virtual world are maintained in a world model, which includes all information as to the current composition of the virtual world. The spatial locations and



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environmental effects presented to each user should be updated smoothly as the world parameters change."); 17:11-23 ("As users move about in the virtual world, they are dynamically connected and disconnected from the conferences of nearby users. This is controlled by the master server 2005. The master server's connection manager 510 periodically examines the world model 515 and determines, for each user X, which users, if any, must be added to X's conference and which users, if any, must be disconnected from X's conference. As discussed earlier, other criteria may also be used to determined which users should be connected to user X's conference. The connection manager 510 implements any changes in user X's conference by sending messages to the conference servers that update the state of the local connection managers.")

- **Osman** at 8:17-25 ("In another embodiment, instead of the portable device tracking the user, a device associated with the user tracks the portable device. For example, headphones 352 include camera 354, and the images taken by camera 354 are used to find the portable device. In one embodiment, the images taken by camera 354 are sent to the portable device for image analysis. Once image analysis determines the location of the portable device, the location of the user in relation to the portable device is deduced, making sound localization possible."), 12:36-46 ("Device Position Tracking module 724 determines the location of the portable device. A plurality of technologies can be used for position tracking such as ultrasound, GPS, RFID, image analysis, triangulation, inertial, etc., or a combination thereof. Head Tracking module 738 determines the position of one or two of the user's ears (which may be determined indirectly by determining a location of the headphones). Head Tracking module 738 may determine the position of the user's ears using one or more different technologies such as image recognition, RFID, ultrasound, infrared, triangulation, etc.")
- **Stafford 805** at 4:46-5:28 ("FIG. 2 illustrates the tracking of the HMD via image analysis, according to one embodiment. In one embodiment, the HMD 208 includes elements that assist in the visual tracking of the HMD. For example, the HMD may include infrared lights 214, Light-Emitting Diodes (LED) 210, and objects with a special shape that is easily recognized via image analysis. For example, one or more spherical objects 212 may be added to the HMD for easy tracking. In addition, the spherical objects 212 may also be illuminated with LED light, infrared light, or any other type of illumination … In another embodiment, an infrared camera 204 analyzes infrared light (e.g., infrared lights 214). The infrared light is not visible to the human eye, but the infrared light is visible to the infrared camera. This way, the HMD may include infrared lights that do not detract from the appearance of the HMD. Additionally, in some environments (e.g., low light or bright light), it may be easier to track infrared light than other type of lights. In yet another embodiment, a regular camera 206, also referred to herein as a mono camera because it has only one lens, is used to track the lights or features in the HMD. In order to determine the depth of the HMD within the field of play with the regular camera, the size of some of the features on the HMD are analyzed in order to detect the depth. The smaller the features are, the further away from the camera the HMD is. In addition, the tracking may also be combined with other types of tracking, such as inertial motion tracking, dead reckoning, ultrasound communication between the HMD in the computing device, etc.")



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- **Gallery** at 5:24-42 ("The HMD of FIG. 3 also features a simplified collision avoidance detection stage: instead of determining its actual position, the HMD is provided with directional proximity sensors 66 which generate a signal if the HMD comes within a predetermined range of another object. The output of the proximity sensors is monitored by a limit detect stage 68 and, if any of them generates a signal, an alarm condition is signalled to the selector stage 64. A slight drawback with the use of proximity sensors is that their detection range is not generally easy to alter, but this at least partly balanced by the simplification they provide to the system. A wired link 70 replaces the telemetry link of FIG. 1: its connection to the HMD should be positioned such as to be unobtrusive to the user, and also such as to be unlikely to activate one of the proximity sensors in normal use. Its interface 24A to the image data processor 12A provides appropriate multiplexing and demultiplexing functions where the link 70 is a single wire link: where a multi-wire cable provides the link, interface 24A may simply be a multi-way connector.")
- **Balachandreswaran** at [0084]-[0085] ("While the scanning system performs scanning for mapping the physical environment, the HMD comprises a local positioning system (LPS) operable to dynamically determine the user's position in 2D or 3D within the physical environment. The LPS may invoke one or more ultrasonic, radio frequency (RF), Wi-Fi location, GPS, laser range finding (LRF) or magnetic sensing technologies. Further, the scanning system and the LPS may share some or all components such that the same system of components may provide serve both scanning and positioning functions, as will be appreciated. The LPS may comprise at least one LPS receiver placed on the HMD or the user's body and operable to receive beacons from LPS emitters placed throughout the physical environment …. ")
- **Sawyer** at [0025] ("Certain embodiments of the present invention comprise a trackable head-mounted display ("HMD") with at least three degrees of freedom in an operating space and optionally one or more sensors with at least two degrees of freedom of positional tracking. The HMD and the optional sensors provide sensory input to a controller, which in turn provides sensory feedback to the HMD or another output device. Without limitation, the HMD may be tethered to a stationary computer (such as a personal computer ("PC"), laptop, or game console), or alternatively may be self-contained (i.e., with some or all sensory inputs, controllers/computers, and outputs all housed in a single head-mounted device)."), [0027] ("FIG. 3 is an exemplary diagram of a transmitter/receiver configuration in an optical positional tracking system that may be used to implement aspects of certain embodiments of the present invention. As depicted in FIG. 3, an exemplary optical positional tracking system comprises a base station (320) that sweeps an optical signal (310) across the tracking volume. Depending on the requirements of each particular implementation, more than one base station may be incorporated, and each base station may generate more than one optical signal. For example, while a single base station is typically sufficient for six-degree-of-freedom tracking, multiple base stations may be necessary in some embodiments to provide robust room-scale tracking for headsets and peripherals. Optical receivers (e.g., 230) are incorporated into the head-mounted virtual reality apparatus (220) or other tracked objects. In certain embodiments, optical receivers are paired with an accelerometer and



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gyroscope Inertial Measurement Unit ("IMU") on each tracked device to support low-latency sensor fusion.")

- **Toshikazu** at [0003] ("Sensors for acquiring the position and/or orientation of the user's viewpoint are widely known. In the mixed reality apparatuses, the position and/or orientation of the user's viewpoint measured by a sensor are set as the position and/or orientation of the virtual viewpoint in a virtual world. Based on the setting, an image of the virtual world is rendered by CG and synthesized with the image of the real world. As a result, the user of the mixed reality apparatus is able to view an image as if a virtual object exists in the real world.")
- **Rickards** at 10:51-11:12 ("The processor 40 is structured to utilize information from the locational sensor 83 and/or other aforementioned sources of locational data to determine the wearer's position on the face of the earth, location of restricted areas, relative locations of potentially hazardous stationary or moving objects around the eyewear wearer, etc. For instance, with regard to determining the wearer's global position, the locational sensor 83 can be structured to receive signals from the Global Positioning System (GPS) via a geomagnetic sensing capability. Such information can be used to determine the wearer's general location and also to determine situational awareness, such as whether the wearer is venturing into restricted areas or perhaps is immobile in excess of a predetermined amount of time, signaling possible incapacitation. In a further embodiment, the processor 40 can utilize the locational data to determine in real time the wearer's vertical and/or horizontal and/or angular orientation thus permitting precise characterization of the wearer's location and orientation in one, two, or three spatial dimensions. Such information can include gyroscopic orientation, speed, and/or acceleration. Here too, such information can be used to determine situational awareness, such as whether the wearer is venturing into restricted areas or perhaps may be horizontally oriented for too long a period, thus may be incapacitated and require assistance. By way of practical example, such information can be utilized to inform a company on the location and status of a worker at a work site, and to facilitate a decision on whether to send help as well as to notify first responders of the wearer's status and location.")
- **Katz 031** at 7:61-8:17 ("The VR console 110 also tracks movement of the VR headset 105 using image data captured by the cameras 120. To track the movement of the headset 105 from the initial position to the new position, the VR console 110 receives 410 image data from the first camera 120A on the headset 105 at the new position of the headset. The image data received from the first camera includes observations of at least a subset of the identified features in the environment. Based on the image data from the first camera 120A, the VR console 110 identifies 412 a first observation of the new position of the headset 105. For example, the VR console 110 determines the distance from the new position of the headset 105 to the features in the environment, and identifies the new position of the headset 105 based on a difference between the determined distance and the distance between the features and the initial position of the headset 105. For the new position of the VR headset 105, the VR console 110 generates 414 offset values representing a difference between the location of the headset 105 determined using the image data from the first camera and the location of the headset determined using the motion data. The VR console 110 stores the location of the



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headset 105 determined using the image data from the first camera 120A, as well as the offset values.")

- **Zalewski 327** at [0070]-[0071] ("FIG. 5 illustrates an example of an electronics unit 90, which may include other functionality, circuitry, firmware, logic, processors, memory, etc. These features are only exemplary and some systems may include more or fewer devices depending on the implementation. In the one example provided in FIG. 5, the electronics unit 90 may be part of the glasses 50. The electronics unit 90 will include a processor 94 which can include a graphics processor or a GPU, or general processor. In some embodiments, multiple processors may be provided, or multicore processors. The processors 94 can be in communication with inertial sensors 91 that may be part of the glasses or head mounted device. The inertial sensors 91 can collect information for motion, movement, dead reckoning, and tracking. This information can be shared with the processor 94. In another embodiment, a plurality of photo diodes are disposed on a surface of the housing. The photo diodes are used for tracking position of the housing using at least one light emitting device positioned in space/room where the housing is to be tracked. For example, the photo diodes can be disposed on the surface of the housing, e.g., with known physical separations to one another. The light emitter can, for example, shoot out light in various directions so that some of the light will contact/reach the photo diodes. A timing profile is calculated or calibrated, so that timing is known or synced with the detection and emitting. In this manner, it is possible to identify when certain of the photo diodes detect light, and because the location of the emitter (e.g., one or two rotating emitters paced in a room) and timing is known, it is possible to identify the position of the housing having the photo diodes. As the emitting and detecting is on-going during the use of the HMD system, tracking of the HMD/housing is facilitated."), [0081] ("In still another embodiment, the front facing cameras of the head mounted device 50 can assist for safety features, such as to advise users when the users are coming close to walls, objects, stairs, or unsafe zones.")
- **Ermilov** at [0133] ("The mechanisms (308, 310, 312) can be implemented using any combination of sensors, including but not limited to: magnetometers, accelerometers, gyroscopic sensors, gravity-based sensors, torque sensors, strain gauges, flex sensors, optical encoder mechanisms, and so on. In addition, some of the mechanisms (308, 310, 312) may receive signals from external systems or sources. For example, the mechanisms (308, 310, 312) may include a sensor for determining the position of a device based on signals received from a satellite-based navigation system (e.g., a Global Positioning System (GPS) system). In addition, or alternatively, the mechanisms (308, 310, 312) may include functionality for determining the position of a device by performing triangulation and/or other processing based on signals received from plural external sources, such as signals received from plural radio towers and/or localized directional antennas, etc. In addition, or alternatively, the mechanisms (308, 310, 312) can include functionality for determining the position of a device using a dead reckoning technique. In addition, or alternatively, the mechanisms (308, 310, 312) can include functionality for determining the position of a device by processing information from local beacons (e.g., Wi-Fi and/or BLUETOOTH beacons, etc.), and so on."), [0292] ("More specifically, FIG. 42 shows the illustrative behavior of the exploration module 430, operating in the explore mode. In this mode, once the explore


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mode is activated by the user, the exploration module 430 determines the current location of the user and the current focus of interest of the user. For example, the exploration module 430 can use any position determination mechanism(s) on the headset 108 and/or on the user device 106 to determine the location of the user at the present time (e.g., using a GPS sensor, etc.). The exploration module 430 can use any orientation mechanism(s) on the headset 108 and/or on the user device 106 to determine the direction at which the user appears to be orienting his body. For example, the orientation mechanism(s) on the headset 108 can determine the direction at which the user's head is pointed, which can be used as a proxy-indication of the user's focus of interest. Alternatively, or in addition, the system 102 may instruct the user to point the user device 106 in the direction that matches his or her focus of interest; in that case, the orientation mechanism(s) of the user device 106 will correctly reflect the user's intended focus of interest. Still other techniques can be used to assess the user's presumed focus of interest.")

- **McCulloch** at 7:34-47 ("In some examples, the capture devices 113 may also be depth sensitive, for example, they may be depth sensitive cameras which transmit and detect infrared light from which depth data may be determined. In other examples, a separate depth sensor (not shown) on the front of the frame 115 may also capture and provide depth data to objects and other surfaces in the field of view. The depth data and image data form a depth map of the captured field of view of the capture devices 113 which are calibrated to include the display field of view. A three dimensional (3D) mapping of the display field of view can be generated based on the depth map. Some examples of depth sensing technologies that may be included on the head mounted display device 2 without limitation, are SONAR, LIDAR, Structured Light, and/or Time of Flight.")
- **Pedrotti** at 4:32-44 ("In another embodiment, a boundary of a selected area is determined, for example, a "safe area" which the user or another person has determined is clear of physical obstacles in the physical world so that the user may move freely without coming into contact with such physical obstacles. The processor similarly tracks the position and orientation of the HMD tracker, and possibly the position and orientation of one or more trackers in the physical controllers, and generates instructions to the HMD to include in a display of a virtual world a visual warning such as a grid or virtual fence when the user comes within a preselected distance of the boundary, thus providing a warning that the user is about to move out of the selected area.")
- **Wan** at 6:64-7:29 ("To perform 6DoF tracking, the example imaging pipeline 300 includes any number and/or type(s) of a 6DoF processor(s) 316. Using any number and/or type(s) of method(s), techniques(s), algorithm(s), circuit(s), etc., the 6DoF processor 316 can process the Chroma sub-sampled images provided by the Chroma sub-sampler 315 to track stationary and/or moving scene features in these the images provided by the Chroma sub-sampler 315. In some examples, only luminance data is used, possibly with inertial measurement data (IMD) 317 provided by an inertial measurement unit (IMU) 318. The 6DoF processor 316 provides determined 6DoF tracking data 332 the VR function portion 330 for further processing. The example image processing portion 310 can also include a stereoscopic image former 319 and a cropper/scaler 320 to support tracking of, for example, hands and fingers. Using any



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number and/or type of method(s), techniques(s), algorithm(s), circuit(s), etc., the stereoscopic image former 319 combines the RGB images 313B and 314B, and the IR images 313C and 314C to form one or more stereoscopic images (e.g., three-dimensional (3D) data) of, among other things, the position and movement fingers and/or hands. This data can be provided to a finger/hand tracker 334 in the VR tracking portion 330. The IR images 313C and 314C can be formed using IR emitters and/or reflectors on the user's hand or elsewhere in a VR environment or system. Because the camera 113 and 114 can have a wider field of view (FOV) than the field of view needed to perform finger and/or hand tracking, the cropper/scaler 320 can crop the image to a smaller size and, when appropriate, can sub-sample the stereo images before tracking is performed. Such a reduction can be useful in reducing processing power and/or memory requirements.")

- **Jarvinen** at 11:1-16 ("The orientation module 71 may be configured to determine the orientation of apparatus 50 relative to a reference. In some cases, the reference may be a particular direction, such as North or another cardinal direction. However, other references may also be employed. As such, in one embodiment, the orientation module 71 may include a compass or other orientation sensor, such as, for example, a gyroscope, configured to determine the heading of the apparatus 50 or direction that the lens of the camera module 36 is pointing. The direction or heading may be determined in terms of degrees (e.g., 0 to 360 degrees) offset from the reference. In some cases, the reference may be fixed (e.g., a fixed directional reference), while in other cases, the reference may be a reference of opportunity such as a prominent feature in an image captured by the camera module or simply an initial orientation.")
- **Zhou** at 1048 ("More generally, the 3D position and speed of the virtual sound source and the position and orientation of user's head are needed. In the following parts, we will introduce two tracking methods to solve this problem … There have been many vision tracking methods for AR reported in recent years. In our first experiment, we used a precise vision-based toolkit for AR tracking reported by Kato and Billinghurst (1999). It used image-processing technology to retrieve 3D position information from a fiducial marker. The 'ARGroove' (Poupyrev et al., 2000) applied this tracking method to get different position and orientation descriptions of the marker movements for which they defined different music. Our first AR experiment system used this tracking method to track the position of virtual sound source which is attached on fiducial marker."), 1051 ("In our research system (Cheok et al., 2002), we use the InterSense IS-900 system (InterSense) for precise motion tracking. The IS-900 system is a hybrid acoustic-inertial six degree of freedom (6 DOF) position and orientation tracking system. It tracks changes in orientation and position by integrating the outputs of its gyroscopes and accelerometers, and corrects drift by using a room-referenced ultrasonic time-of-flight range measuring system. It can obtain a resolution for position of 15 mm."), Figs. 1, 3
- **Jin** at 308-09 ("Using a head-tracker and head-mounted display, the user is placed at the scene of the crime and is free to rotate his or her head to choose any point of view (Figure 1). Given the relatively narrow field of view provided by contemporary headmounted displays (in this case, a Daeyang i-visor DH-4400VPD 3D), it was deemed necessary to provide a soundtrack that would present the user with spatial cues



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that could draw his/her attention to any action that may be currently out of view."), 309 ("Although the spatial trajectories were provided for only one viewing angle, the soundscape had to be rendered for all viewing angles to allow for head-tracking. With the headmounted display (HMD), the participant could face any direction, and look up and down to view the panoramic scene and could change their viewing direction at any time. Most head-orientation sensors provide head orientation data in terms of three angles: azimuth, elevation, and roll. Given that it requires approximately 400 azimuth and elevation combinations to cover the sphere with 10 degrees of separation, disregarding directions lower than -45 degrees in elevation, and that there are approximately 19 roll positions in 10 degree steps from -90 degrees to +90 degrees, this implies rendering the soundscape for 400 x 19 or 7600 viewing angles. The sound data corresponding to this number of viewing angles cannot be streamed from a hard disk in real-time with current desktop computers (e.g., it requires a hard disk access rate of 1.25GBytes/second)."), 311 ("Subjective testing of 3DApe was carried out using a headphone (Sennheiser ES2200), head-orientation sensor (Intersense InertiaCube2), and head-mounted display (Daeyang I-Visor 3D).")

- **Clement** at Abstract ("A system and method of operating an audio visual system generating a virtual immersive experience may include an electronic user device in communication with a tracking device that may track a user's physical movement in a real world space and translate the tracked physical movement into corresponding movement in the virtual world generated by the user device. The system may detect when a user and the user device are approaching a boundary of a tracking area and automatically initiate a transition out of the virtual world and into the real world. A smooth, or graceful, transition between the virtual world and the real world as the user encounters this boundary may avoid disorientation which may occur as a user continues to move in the real world, while motion appears to have stopped upon reaching the tracking boundary."), 3:20-4:5 ("The HMD 100 may also include a sensing system 160 including various sensing system devices 162-164 and a control system 170 including various control system devices 171-176 to facilitate manual user control and automated control of the HMD 100. … In the example embodiment shown in FIG. 2, the sensing system 260 includes a light sensor 262, a distance/proximity sensor 263 and an audio sensor 264, and the control system 270 includes a power control device 271, a pause control device 272, a manual audio control device 273, a manual video control device 274, a rotation control device 275 to control rotation of the housing relative to the frame, an optical adjustment control device 258 to adjust optical components of the device 250, and a transition control device 276 to control transitions between the virtual environment and the ambient environment."), 4:15-5:16 ("In some embodiments, this type of motion tracking in the space may be accomplished by, for example, a tracking device such as a camera positioned in the space, and in communication with a base station generating the virtual world in which the user is immersed. This base station may be, for example, a standalone computing device, or a computing device included in the HMD worn by the user."), 5:17-54 ("Regardless of the shape or contour of this zone Z, the zone Z may represent, for example, a warning threshold or boundary associated with the position of the user A in the space 300 relative to the tracking area 320 of the tracking device 310. At positions 1, 2 and 3, the user A and the zone Z surrounding the user A are completely within the tracking area 320, and physical



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movement of the user A in the space 300 may be translated to corresponding movement in the virtual world as described above. At position 4, the user A is within the tracking area 320, but in close proximity to the edge or boundary of the tracking area 320, with a portion of the zone Z surrounding the user A outside of the tracking area 320. At position 5, the user A and the zone Z surrounding the user A are completely outside of the tracking area 320."), 5:55-6:6 ("In some embodiments, the tracking device 310 may not just track the physical position and movement of the user A in the space 300, but may also detect when the user A is within a predetermined distance, or threshold, of a boundary or edge of the tracking area 320, at which loss of tracking may be imminent."), 6:7-56 ("As shown in FIG. 3C, the user is completely within the tracking area 320 at position 3A. As the user moves from position 3A to position 3B, the user approaches the point at position 3B at which the edge of the established 3 foot radial zone meets the boundary of the tracking area 320. As the HMD 100 and/or the tracking device 310, or other component of the system, determines that the user is positioned within the preset threshold (in this particular example, 3 feet of the boundary of the tracking area 320, as at position 3B), the system 100 may initiate a gradual transition out of the virtual world. At position 4, the user has moved closer to the boundary of the tracking area 320 (for example, within 1 foot of the boundary as shown in the example illustrated in FIG. 3C). At position 4, the transition out of the virtual world may be at least partially complete, with the transition process fully complete by the time the user reaches position 5 and is fully outside of the tracking area 320."), 7:4-16 ("In some embodiments, the tracking device 310 may detect the user's proximity to a boundary of the tracking area 320, or that the user is within a threshold distance of a boundary of the tracking area 320. In some embodiments, the HMD 100 may include a sensor that detects that the user user's proximity to a boundary of the tracking area 320, or that the user is within a threshold distance of a boundary of the tracking area 320. For example, one of the sensors of the sensing system 160 (such as, for example a proximity sensor 163) and/or the camera 180 of the HMD 100 may detect this proximity to the boundary, and the control system 170/processor 190 may initiate the transition process as described above."), 12:20-29 ("In the absence of a specific command to transition from the virtual world, the HMD 100 and/or the tracking device 310 may determine a current position of the user in the tracking area 320 at block 1030, as described above. If it is determined, at block 1040, that the user is within a set threshold or range of the boundary of the tracking area 320, at which loss of tracking by the tracking device 310 may be imminent, the transition process may be initiated at block 1050. The transition process is shown in more detail in FIG. 11."), 12:30-13:11 ("As shown in FIG. 11, a current distance between the user and the boundary of the tracking area 320 may be detected, and may be compared to a previously detected distance between the user and the boundary, at block 1051. Based on this comparison, a direction and/or speed and/or acceleration of the movement of the user may be determined, at block 1052, to confirm the user is approaching the boundary at block 1053. If it is confirmed at block 1053 that the user is approaching/nearing the boundary (and is about to enter an area where the tracking device 310 may not be able to continue to track the user's physical movement in the space 300), a transition profile may be implemented, at block 1054, based on various factors, such as, for example, the virtual environment, the real world space 300 in which the virtual environment is implemented, direction and/or speed



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and/or acceleration associated with the movement of the user, and other such factors."), Figs. 1A-1C, 2, 3A-3C, 11.

**5. Boundary or safety systems for gameplay**

Boundary or safety systems and methods for gameplay, such as in extended reality environments, were well known to a POSA at or before the purported priority dates of the Asserted Claims. Illustrative examples of such systems and methods are disclosed in at least the following:

- **Begault 2000** at 12 ("An example is the problem of simulating the tactile sensation of walking into a virtual wall; hence, some have provided a 'crashing' sound through headphones when a person walks into a virtual boundary."), 173 ("In virtual reality, one can walk through walls and objects; but by activating auditory information in the form of a bumping or crashing sound, the user receives feedback that a particular physical boundary has been violated.")
- **Gum** at [0009] ("In one aspect, a method for setting virtual representations of an area for conducting virtual operations is provided. The method of this aspect comprises: (a) setting boundaries of an area with a wireless communications device enabled with location determination capabilities; and (b) marking the position of at least one obstacle in the area with the wireless communications device. The wireless communications device may include location determination capabilities that utilize a satellite positioning system such as a global positioning system receiver. The wireless communications device may also transmit the boundaries of the area and the position of the at least one obstacle to a server. Boundaries may be set in any of a number of ways, such as marking corners of quadrangle shaped boundaries, marking a center point of a boundary that has known dimensions to the center point, and marking two or more points and designating a relationship between the marked points and the area, to name but a few examples. Obstacles may be marked by marking the position of an obstacle when the wireless communications device is located in proximity to the obstacle and designating a size of the obstacle, for example."), [0030] ("… When users are playing the virtual reality game, they continue to carry the wireless communications devices 100 that monitor the location of the users, and in the event users exit the playing area boundary 24, one or more types of alerts may be generated by the wireless communications device indicating that the position of the user is outside of the playing area boundary 24. Similarly, if a user comes within a certain proximity of an obstacle 30 within the playing area boundary, the wireless communications device may generate one or more alerts based on the location of the user. As is understood, position determination systems often include an error calculation that may be used to estimate an error in the calculated position of an SPS receiver. In cases where estimated position error is relatively high, this error estimate may be used to determine the probability that any given boundary is exceeded or not, and alerts generated based on such probability. Furthermore, in some embodiments, the location of one or more obstacles 30 may be dynamic, thus moving around within the playing area boundary. For example, the obstacle 30 may be associated with one of the players of the virtual reality game, and



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in the event that another player of the virtual reality game comes within a predefined proximity of the obstacle, an event may happen to the second player. Similarly, the obstacle 30 may be a static obstacle and represent a hazard within the playing area boundary, such as a hole or a water hazard, and thus players carrying wireless communications devices 100 are alerted in the event that they come within a certain proximity of the obstacle 30, and may thus avoid the obstacle.")

- **Geisner** at [0124] ("While playing the game, each player's personal A/V apparatus 502 will monitor the player's three dimensional location and the boundaries (step 620, see also FIG. 6M). If the player comes close to a boundary, the personal A/V apparatus will automatically highlight the boundary by changing its color, pointing to it with an arrow (or other shape), drawing a red line next to it, etc. If the user crosses over the boundary, the personal A/V apparatus 502 will identify the infraction to the player and transmit that infraction to the server (Supplemental Information Provider 504 and/or Central Control and Information Server 522). In step 622, each personal A/V apparatus 502 will transmit game state for storage to the Supplemental Information Provider 504. In one embodiment, step 622 is performed continuously or periodically. The game information is stored in step 624 by the Supplemental Information Provider 504 and/or Central Control and Information Server 522 for future access. See also the example game state data of FIG. 6N."), [0131] ("In another approach, one or more points in a physical environment are defined as points on boundary lines of the game space. Points of a game space can be defined in different ways. In one approach, a gaze direction of the user is used to determine a gazed-upon point in a physical environment. Boundary lines can be created by defining and joining multiple points. A boundary line can be straight or curved. A point by itself could also be a location of interest and not necessarily part of a boundary line. A user could also move to different locations in an area to define points in the game space, relying on a location detection capability of the personal A/V apparatus."), [0160] ("For example, the appearance of a boundary may be change[d] by being highlighted if a user comes near it (or on it, within a specified distance from it, and/or remaining there for a specified amount of time), as depicted by the image 1200 as a highlight of the circular boundary 814 in FIG. 12. Regarding a virtual object, as an example, the lamp 1016 of FIG. 10D may change its appearance by lighting up if a user comes near it and/or performs some gesture such as kicking it (as a variation of the game of kick the can).")
- **Bennett** at [0089] ("Some applications access over a network stored adaptive AR environment criteria 342 for effecting the placement and display of one or more virtual objects in a 3D mapping of an environment during their execution. For example, a gaming application may receive user input identifying boundaries for a playspace in which virtual objects can be positioned. For example, the user input data may be image and depth data from a capture device on the display device captured while a user is turning his head, gaze data captured while the user is gazing at boundary points and perhaps audio data captured by the microphone of the user speaking a command like "boundary". In other examples, an application automatically determines a playspace or operation space for the application based on a 3D mapping of the user environment or location. A 3D mesh may be used to represent the mapping of the environment. The adaptive AR environment criteria are flexible in that they provide fallback criteria or


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alternative criteria based on the real features (e.g. real surfaces, lighting, size dimensions of application operation space) mapped in the user environment.")

- **Gallery** at 3:4-11 ("Suitably, user input means may be provided, coupled to the motion detector, by use of which a user may enter physical values defining the said limits of HMD movement. Alternatively, some form of set-up routine may be provided for in which the user positions the HMD at positions of maximum permissible displacement, which positions are logged by the motion detector prior to the user entering the virtual environment.")
- **Sawyer** at [0059] ("First, a user can simply walk around in the real operating space, holding his or her controller and moving it along some or all of the walls/floor/ceiling of the operating space. The measurements taken via this process are transmitted to the chaperoning system controller using any appropriate technique, as known to skilled artisans. Based on these absolute measured positions, the systems according to aspects of the present invention then calculate the smallest polyhedron that contains all of the positions in which the controller has been detected. Second, rangefinders of various types that are known to skilled artisans (e.g., ultrasound, laser) may be integrated into particular implementations, and these may generate the necessary information regarding the boundaries of the operating space, with little or no intervention required by a user."), [0034]-[0037] ("Without limitation, definition of Soft Bounds can be made in the following ways (including combinations), depending on the requirements of each particular implementation: By entering data in a computer by means of mouse and keyboard; By moving a tracked object (HMD or other worn sensors such as a game controller) to the n corners of the operating space; and/or By wearing a tracked HMD in one location, looking (either physical rotation of the HMD or rotation of the eyeball if the HMD has gaze-tracking technology) at each of the n corners of the operating space from at least two places in the operating space (triangulating the corner that is looked at)."), Figs. 5, 7
- **Jerald** at 213 ("Warning Grids and Fade-Outs. For a user approaching the edge of tracking, a real-world physical object not visually represented in the virtual world (e.g., a wall), or the edge of a safe zone, a warning grid (Figure 18.3) or the real world can fade in to provide a cue to the user that he should back off. Whereas such feedback can cause a break-in-presence, it is better than the alternative of the loss of quality tracking that results in a worse break-in-presence and injury. Once tracking is no longer solid or latency exceeds some value, the system should quickly fade out the display to a single color to prevent motion sickness. Such problems are most easily detected by detecting tracking jitter or a decreased frame rate. Alternatively, for systems with low-latency video-see-through capability, the system can quickly fade in the real world.")
- **Toshikazu** at [0026] ("In each of the following embodiments, the positions of the boundary-measured points are presented to the user of the mixed reality apparatus when the user enters the warning area 50 and a warning is issued. Hereinafter, each of the embodiments is described in detail."), [0076] ("By virtue of this, it is possible to visually notify the user of this apparatus that the user's current position is near the boundary of the movable area 60. Furthermore, in a case where it is determined that the viewpoint position exists inside the warning area 50, the plane or the boundary line



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of the warning area 50 may be rendered by CG instead of the boundary-measured value rendering CG to notify the user of this apparatus that the user is near the boundary of the movable area 60.")

- **Latta** at [0027] ("In other embodiments, the arena may be configured by a user such that one or more parameters of the virtual arena are selected by a user. For example, the user may select a size, position, orientation, shape, etc. of the virtual arena by providing a user input. In some embodiments, a user may point to a location in the room and a selected virtual arena may be placed at that location. The virtual arena may have an altered appearance during configuration to indicate that the virtual arena is being customized. Upon confirming parameters of the virtual arena, the appearance of the virtual arena may change to indicate that configuration is complete. The virtual arena may also be positioned modularly such that the user selects a location for various bounds of the virtual arena until a virtual arena is defined. For example, a user may point at a location for each boundary point of a modular virtual arena to define the bounds of the virtual arena.")
- **McCulloch** at 20:4-27 ("One of the advantages of using a near-eye, augmented reality display device system is the ability to execute an application wherever you are and using your current physical environment as a factor in the execution of a game. Some applications store adaptive virtual environment rules 342 for effecting the placement and display of one or more virtual objects in a 3D mapping of an environment during their execution. For example, a gaming application may receive user input identifying boundaries for a playspace in which virtual objects can be positioned. For example, the user input data may be image and depth data from a capture device on the display device captured while a user is turning his head, gaze data captured while the user is gazing at boundary points and perhaps audio data captured by the microphone of the user speaking a command like "boundary". In other examples, an application automatically determines a playspace or operation space for the application based on a 3D mapping of the user environment or location. A 3D mesh may be used to represent the mapping of the environment. The adaptive virtual environment rules are flexible in that they provide fallback rules or alternative rules based on the real objects and real features mapped in the user environment. An example of a real feature is lighting. Another example is size dimensions.")
- **Pedrotti** at 2:44-59 ("Another embodiment discloses a system to assist a user in remaining in a selected area of the physical world, the user wearing a head-mounted display (HMD) and holding a handheld controller, comprising: a controller tracker on the handheld controller which provides information regarding a position of the handheld controller; and a processor configured to: receive as an input a definition of a boundary of the selected area; determine the position of the handheld controller in the physical world using information from the controller tracker; generate and output instructions to the HMD to display on the HMD a virtual world; determine from the position of the handheld controller that the hand-held controller is within a first preselected distance from the boundary; and generate and output instructions to the HMD to display on the HMD a first visual warning in the virtual world"), 12:40-50 ("In one embodiment, when the user's head and/or hand approaches to within a preselected distance, for example, one foot (again, either preprogrammed into the



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processor or user selectable), of the boundary of the selected area the processor generates a warning that the user is close to the boundary so that the user can take action to avoid the boundary and thus potential collision with the physical objects. In some embodiments, the processor can generate this warning by generating instructions to the HMD display to add some virtual element to the virtual world which can be seen by the user."), 12:60-66 ("In addition, since the hand of the user 1002 is within the preselected distance of the boundary of the selected area, the processor generates instructions to the HMD to generate the visual warning. As illustrated in this embodiment, this visual warning is in the form of a grid of lines or a 'virtual fence' located at the boundary, as indicated in FIG. 11 by the dashed lines 1114."), 13:20-23 (describing a "cylindrical projection" for the "virtual fence"), 13:63-67 ("If the user's head or hands go beyond the boundary as determined by the trackers, the processor can provide additional messaging or warning, such as text or auditory warnings, or an additional visual warning, that persists until the user returns to the selected area within the boundary."), 14:56-15:3 ("In still another embodiment, an irregularly shaped area is defined, as shown in FIG. 14. A boundary 1404 around an irregularly shaped area, which is not circular, can be defined, for example, by having the user walk around a perimeter chosen by the user with one of the trackers to define the outer boundary of a selected area, for example, one in which there are no obstacles. The processor determines the position of the tracker at a number of sampling points as the user moves around the chosen perimeter, and from those points determines the boundary 1404. This approach may be desirable when the size of a circle 1406 that can be inscribed within boundary 1404 is limited by nearby objects 1408, but there is some additional room between objects 1408 in which the user can be free to move without risk of collision with objects 1408."), 15:13-22 ( "the processor receives as an input information from which the processor can define a boundary surrounding a selected area, for example, one in which there are no physical obstacles … this information will typically be entered by a user or someone else, or may in part or whole be received from a tracker, and may be the radius and location of the center of a circle of a determined diameter that is clear of obstacles, or positions around an irregularly shaped area provided by the user or other person walking around the boundary holding a tracker"), Figs. 11-14

**6. Head related transfer functions**

Head related transfer functions ("HRTFs") and systems and methods for using same with binaural audio were known before the purported priority dates of the Asserted Claims. Illustrative examples of such HRTFs and related systems and methods are disclosed in at least the following:

- **Otto 440** at 10:59-11:13 ("FIG. 7a illustrates the underlying approach used in binaural mode operation according to the present invention, where an array a speakers 10 is configured to produce specially-formed audio beams 12 and 14 that can be delivered separately to the listener's ears 16L and 16R. Using the mode, cross-talk cancellation is inherently provided by the beams. The use of binaurally encoded beams enables an effective presentation of spatialized sound, where sounds originating from a first source can be delivered to the listener to sound as if emanating from a different location as a



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second source. As an example of a spatialized sound application, FIG. 7b illustrates a hypothetical video conference call with multiple parties at multiple locations. When the party located in New York is speaking, the sound is delivered as if coming from a direction that would be coordinated with the video image of the speaker in a tiled display 18. When the participant in Los Angeles speaks, the sound may be delivered in coordination with the location in the video display of that speaker's image. On-the-fly binaural encoding can also be used to deliver convincing spatial audio headphones, avoiding the apparent mis-location of the sound that is frequently experienced in prior art headphone set-ups."), Figs. 7a, 7b

- **Schroder** at 14:32-15:7 ("Figure 15 shows a schematic illustration of an arrangement for tracking the virtual direction of an aural event. Audio signals AudioL, AudioR coming from a source which is not shown in the figure are sent to a control circuit HRTF which processes the audio signals in line with a head-related transfer function (HTRF) . A signal RP representing the position of the head in relation to the trunk of the listener is supplied to the control circuit HRTF. The HRTF control circuit produces output signals for the left and right channels, which permit virtual localization of the reproduced aural event, taking into account the relative position of the head in relation to the trunk."), Fig. 15.

- **Pedersen** at 3:53-65 ("The HRTF changes with direction and distance of the sound source in relation to the ears of the listener. It is possible to measure the HRTF for any direction and distance and simulate the HRTF, e.g. electronically, e.g. by filters. If such filters are inserted in the signal path between an audio signal source, such as a microphone, and speakers worn by a listener for emission of sound towards the respective ears of the listener, the listener will achieve the perception that the sounds generated by the speakers originate from a sound source positioned at the distance and in the direction as defined by the transfer functions of the filters simulating the HRTF in question, because of the true reproduction of the sound pressures in the ears.").

- **Hammershoi** at [0053]-[0054] ("As sketched in FIG. 3 the determined 3D positions PL(X,Y,Z), PR(X,Y,Z) are applied to a binaural audio processor. In case of a VR application, the binaural audio processor may perform binaural synthesis by convolved an audio signal with HRTFs or selected based on the 3D positions PL(X,Y,Z), PR(X,Y,Z), and the resulting binaural audio data are wirelessly transferred to the audio inserts that presents corresponding binaural signals to the listener. Since the position tracking of both ears allow an estimate of an actual ITD for the listener, it is possible to adapt HRTFs, e.g. parameterized HRTFs, stored in a data bank in order to make the HRTFs better fit the individual listener. A simple implementation could be to have e.g. three sets of HRTFs stored: one to fit large head sized, one for medium head sizes and one for small head sizes. Hereby a better binaural synthesis with improved localization performance may be obtained compared to a situation where one set of standardized HRTFs is used for all listeners.")

- **Nystrom** at 8:10-41 ("FIG. 6 is a functional block diagram of HRTF device 206. As shown, HRTF device 206 may include HRTF generator 602. In some implementation, HRTF generator 602 may be implemented by processor 402 executing instructions stored in memory 404 of user device 204. In other implementations, HRTF generator



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602 may be implemented in hardware. HRTF generator 602 may generate HRTFs, select HRTFs from the generated HRTFs, or obtain parameters that characterize the HRTFs based on information received from user device 204. In implementations or configurations in which HRTF generator 602 selects the HRTFs, HRTF generator 602 may include pre-computed HRTFs. HRTF generator 602 may use the received information (e.g., environment parameters) to select one or more of the pre-computed HRTFs. For example, HRTF generator 602 may receive information pertaining to the geometry of the acoustic environment in which a sound source virtually resides. Based on the information, HRTF generator 602 may select one or more of the pre-computed HRTFs. In some configurations or implementations, HRTF generator 602 may compute the HRTFs or HRTF related parameters. In these implementations, HRTF generator 602 may apply, for example, a finite element method (FEM), finite difference method (FDM), finite volume method, and/or another numerical method, using 3D models to set boundary conditions. Once HRTF generator 602 generates or selects HRTFs, HRTF generator 602 may send the generated/selected HRTFs (or parameters that characterize transfer functions (e.g., coefficients of rational functions)) or data that characterize a frequency response of the HRTFs to another device (e.g., user device 204).”), Fig. 6.

- **Begault 2000** at 41 (“The spectral filtering of a sound source before it reaches the ear drum that is caused primarily by the outer ear is termed the head-related transfer function (HRTF). The binaural HRTF (terminology for referring to both left- and right-ear HRTFs) can be thought of as a frequency-dependent amplitude and time-delay differences that result primarily from the complex shaping of the pinnae.”) *id.* at 44 (“While individualized or personal HRTFs are shown in Figures 2.13-2.15, it is important to note that most 3-D sound systems are incapable of using the HRTFs of the user; in most cases, nonindividualized (generalized) HRTFs are used, Nonindividualized HRTFs can be derived from individualized HRTF averages, although this can potentially cause the minima and maxima of the spectra to be diminished overall. Usually, a theoretical approach--physically or psychoacoustically based--is used for deriving nonindividualized HRTFs that are generalizable to a large segment of the population (see Chapter 4, ‘Calculation of Generalized HRTF Sets’).”), 49 (“Within a 3-D sound system, inclusion of ITD and IID based on the spectral alteration of the HRTF is considered to be more accurate and realistic than the simple IID and ITD differences described previously in the discussion on lateralization. But this is probably true only in a qualitative sense, and not in terms of azimuth localization accuracy. A study by Middlebrooks (1992) examines the role of spectral cues as they contribute to accuracy of horizontal position. Only IID cues were used, with narrow bands of noise at high frequencies. He reasoned that if the HRTF spectrum contributed to IID localization independent of overall IID, then noises filtered into narrow bands should be localized with more error than full-spectrum noise that could "take advantage" of the HRTF. This turned out not to be true; azimuth location turned out to be just as accurate across both conditions.”), 99 (“Changing HRTF spectra as a function of head movement is generally considered to improve overall localization performance. It does not necessarily follow that virtual source movement will improve performance.”), 99-100 (“important cues for manipulating a sound source's lateral position are (1) interaural intensity differences and (2) interaural time differences. Over



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headphones, these cues are effective in themselves for lateralization--moving a sound source along a line inside the head. The spectral changes caused by the HRTF are the cues that help externalize sound images, disambiguate front from rear, and impart elevation information; the inclusion of the binaural HRTF is fundamental for a 3-D sound system that relates natural and synthetic spatial hearing. Changing HRTF spectra as a function of head movement is generally considered to improve overall localization performance. It does not necessarily follow that virtual source movement will improve performance. Nonindividualized HRTFs result in poorer localization than individualized HRTFs, but the latter are usually impractical for use in most applications. Under optimal conditions--individualized HRTFs, broadband signal, and target positions at lower elevations (eye level and below)—the localization error for virtual images is only slightly greater than under normal listening conditions. There are also notable localization performance differences between individuals."), 100 ("Within a virtual reality or multimedia application, 3-D sound processing is almost always best accomplished digitally, using audio DSP chips to manipulate signal sources."), 101 ("In this example, two DSPs are used to spatialize two sources to two different positions."), 105-106 ("The basis of 3-D sound processing lies in imitation of the spatial cues present in natural spatial hearing, where the binaural HRTF imposes spatially dependent spectral modifications and time delays on an incoming wavefront to the hearing system. In virtual spatial hearing, it is possible to imitate these modifications using a DSP as a digital filter. One can obtain HRTF data by several methods (described later) and then use digital filters--specifically, two different h(n) s, termed a binaural impulse response--to produce a desired virtual acoustic source position. But before turning to this process, it's necessary to cover the basics of digital filtering."), 112 ("The 3-D sound system designer in most cases will want to obtain a library of HRTF measurements, from which particular sets can be selected on the basis of either user preference or behavioral data. Several corporate and university research projects are underway where HRTF measurements are collected and subsequently utilized for digital filtering. Someday, a collection may be available on a CD-ROM; already, some HRTFs are available over computer networks (see Chapter 6). But because the process is extremely time consuming and relatively difficult, most people who have gone to the trouble to do the work are unwilling to merely give away the data. A notable exception is the paper by Shaw and Vaillancourt (1985), essentially an archival report of HRTF measurements discussed in an earlier paper of Shaw (1974). This paper gives HRTF magnitude data in numerical form for 43 frequencies between 0.2-12 kHz, the average of 12 studies representing 100 different subjects. However, no phase data is included in the tables; group delay simulation would need to be included in order to account for ITD."), 118 ("A review of the literature shows that KEMAR's HRTFs have been used many times in both 3-D sound applications and localization studies (e.g., Kendall, Martens, and Wilde, 1990)."), 139 ("Some of these methods have been worked into 3-D sound systems, where HRTF processing is applied not only to the direct sound but to the indirect sound field as well, resulting in a synthetic spatial reverberation."), 140 ("Anechoic HRTFs are taken from a library of measurements, and are used to position the virtual sound source's azimuth and elevation position."), 170 ("The AL-204 (see Figure 5.9), was an early four-channel DSP-based convolution device that used HRTFs based on measurements of the KEMAR mannequin head (Figure 4.25) made at



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Northwestern University (cf. Kendall, Martens, and Wilde, 1990). This hardware was designed to provide auditory location coordinates and spatialized audio input from flight control and other onboard systems."), 179 ("MAW allows teleconference participants to wander around in the virtual room and to focus their voice toward particular conference participants by using a binaural HRTF to process each virtual source"), 182 ("The gain and azimuth heard for each icon is linked to the relative position on the graphic display; a mouse can be used to make sources louder by resizing the icon. MAW allows teleconference participants to wander around in the virtual room and to focus their voice toward particular conference participants by using a binaural HRTF to process each virtual source. Distance cues also are modeled in the system, and one can leapfrog between teleconference sessions or be at several simultaneously simply by cutting and pasting one's personal graphic icon to different environments, each represented by a separate window. One can also move to a "private conference" by moving the icons of the participants to a special region on the computer screen, symbolized as a separate room.")

- **Ballas 439** at 2:38-53 ("A head tracking system also mounted on the frame where speakers are mounted determines the location and orientation of the listener's head and provides the measurements to a computer system for audio signal processing in conjunction with a head related transfer function (HRTF) filter to produce spatialized audio. The HRTF filter maintains virtual location of the audio signals, thus allowing the listener to change locations and head orientation without degradation of the audio signal. The system of the present invention produces virtual sound sources that are externally perceived and positioned at any desired orientation in azimuth and elevation from the listener."), Fig. 1.

- **Boustead** at 10:16-48 ("The generation of a binaural audio signal for each one of the downstream audio signals 124 may be performed by processing the (mono) downstream audio signal through a spatialisation algorithm. Such an algorithm could be the filtering of the samples of the downstream audio signal using a pair of head related transfer functions (HRTFs), in order to provide a left and right ear signal. The HRTFs describe the filtering that would have naturally occurred between a sound source (of the downstream audio signal) positioned at a particular location in space and the ears of the listener. The HRTFs include all the cues for the binaural rendering of the sound, such as interaural time difference, interaural level difference and spectral cues. The HRTFs depend on the location of the sound source (i.e. on the talker location of the downstream audio signal). A different, specific pair of HRTFs may be used for each specific location within the conference scene. Alternatively, the filtering characteristics for a particular location can be created by interpolation between adjacent locations that HRTFs are available for. Hence, the terminal 120 may be configured to identify the talker location of a downstream audio signal from the associated metadata. Furthermore, the terminal 120 may be configured to determine an appropriate pair of HRTFs for the identified talker location. In addition, the terminal 120 may be configured to apply the pair of HRTFs to the downstream audio signal, thereby yielding a binaural audio signal which is perceived as coming from the identified talker location. If the terminal 120 receives more than one downstream audio signal within the set of downstream audio signals 123, the above processing may be performed for each of the



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downstream audio signals and the resulting binaural signals may be overlaid, to yield a combined binaural signal.")

- **Cohen 1993 I** at 470 ("Binaural localization cues may be captured by head-related transfer/functions (HRTFs), impulse responses measured for the head and pinna (outer ear) of human or dummy heads. For each spherical direction, a left-right pair of these transfer functions is measured and stored as FIR filter coefficients. Sound can then be spatialized by driving digitized input signals through these hrtfs in a convolution engine, creating psychoacoustic localization effects by introducing binaural spatial cues into an originally monaural channel, 'placing' the channel within the perceptual space of the user (Kendall & Martens, 1984; Gehring, 1987; McKinley & Ericson, 1988; Richter & Persterer, 1989; Wenzel, 1992).")
- **Curry** at 7:64-8:15 ("In a preferred embodiment, depending on the virtual location of a participant, the spatial sound conference bridge selects a head-related transfer function relating to the relative virtual position of each participant. The head-related transfer function unit 205 processes the monaural signal from a participant and creates two new sound signals, one for each ear of a listener. The head-related transfer function unit 205 can be a signal processor, such as the Convolvotron available from Crystal River Engineering in Palo Alto, Calif. The two new sound signals combined create a spatialized sound signal. For example, the head-related transfer function imparting a spatialization of 'two locations to the right' may be applied to the signal from port 201. The head-related transfer function imparting a spatialization of "one location to the right" may be applied to the signal from port 202. Correspondingly, the head-related transfer function of "one location to the left" may be applied to the signal from port 203, and the head-related transfer function of "two locations to the left" may be applied to the signal from port 204.")
- **Chou** at 13:44-14:26 ("Referring again to FIG. 8, the spatialized audio representation of the visually impaired person's current physical environment can optionally be further enhanced by using the HRTF for the person to spatialize one or more additional virtual sound sources at prescribed spatial coordinates from the perspective of the visually impaired person's head, where each additional virtual sound source communicates a specific type of direction information to the visually impaired person (block 806). Exemplary types of direction information that can be communicated by a given additional virtual sound source include a prescribed cardinal direction (i.e., north, or south, or east, or west), or a prescribed ordinal direction (i.e., northeast, or southeast, or southwest, or northwest), or a waypoint, among others. In a situation where the standalone environment sensing device includes the aforementioned location sensor, the sensing device can be integrated with a conventional mapping and navigation application, and the spatialized audio representation of the visually impaired person's current physical environment can optionally be yet further enhanced by providing the person with audible navigation information which is specifically related to the environment. Exemplary mapping and navigation applications which can be use include Google Maps and Bing™ (a trademark of Microsoft Corporation) Maps, among others. Exemplary types of audible navigation information that can be provided include verbal walking directions, a verbal explanation of one or more aspects of the environment (such as the name of a road the person is on, the name of a restaurant or


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store the person is approaching, and the like), and verbal directions to a particular landmark in the environment, among others. Referring again to FIG. 8, in a situation where the visually impaired person's current physical environment includes one or more fast moving objects, the spatialized audio representation of the environment can optionally be yet further enhanced by using the HRTF for the person to spatialize a virtual sound source at spatial coordinates, from the perspective of the person's head, that correspond to the current locus of the fast moving objects, where the virtual sound source simulates the sound of the fast moving objects and thus helps the person locate them (block 808). By way of example, but not limitation, in the aforementioned situation where the visually impaired person is approaching a busy street having cars thereon that are fast approaching from a distance (such that the person can't yet hear them), a virtual sound source that simulates the sound of a busy street with fast moving cars can be spatialized at spatial coordinates, from the perspective of the person's head, corresponding to the current locus of the street. This virtual sound source will thus audibly alert the visually impaired person of the cars that are fast approaching.”), Fig. 8

- **Gardner** at 12:51-13:5 (“As shown in FIG. 3B, the spatial locations of users in E's conference depend on the relative virtual locations of E, F, and H, and the virtual orientation of E. The generated spatial locations will, therefore, change as E changes his orientation or moves about, and will also change if users F and H move. Similarly, the reverberation characteristics of E's conference will depend on the characteristics of the enclosing virtual room, if any. It is also possible to model different reverberation effects if, for example, user H is in a virtual room adjoining E's room, and which has reverberant characteristics different from E's room. In this case, the sound of H's voice can be rendered with a different reverberation. Additional environmental cues that may be modeled include object occlusion, source directivity, and the Doppler motion effect. Object occlusion refers to the modification of sound caused by an occluding object between the sound and the listener. For example, with continued reference to FIGS. 3A and 3B, if user F is behind a wall but still audible, the sound of her voice can be altered to model the occluding effect of the wall. Source directivity refers to the fact that a source may project sound non-uniformly. For example, a human talker projects low frequencies uniformly in all directions, but high frequencies are transmitted primarily in the direction the talker is facing. The Doppler motion effect is a pitch change of the sound caused by the relative motion of the sound and the listener. This effect is audible only if users are rapidly moving in the virtual world, which might occur in game play if, for example, one of the users is riding a virtual vehicle. The positions and orientation of users in the virtual world are maintained in a world model, which includes all information as to the current composition of the virtual world. The spatial locations and environmental effects presented to each user should be updated smoothly as the world parameters change.”)
- **Li 305** at 15:53-16:11 (“In an embodiment as disclosed in the detailed description of FIGS. 1-5, the 3D sound processing application measures multiple head related transfer functions (HRTFs) in communication with the simulator apparatus 300 exemplarily illustrated in FIGS. 3A-3C and FIG. 4. The 3D sound processing application dynamically processes the recorded sound tracks with the measured head related



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transfer functions based on the acquired user selections to generate the configurable 3D binaural sound. With respect to music listening, when a user wants a sound track to come from one particular direction, the user enters his/her preference by placing an icon on a corresponding location on the generated configurable sound field via a touch screen of the user's computing device. The 3D sound processing application then applies the corresponding HRIR for convolution in the time domain or applies the corresponding HRTF for a multiplication in the frequency domain. Using a bank of measured HRIRs or HRTFs, the 3D sound processing application accurately positions the acoustic sound source on the spot that the user prefers. Thus, the user can place musical instruments where he/she prefers or imagines on the generated configurable sound field via the GUI, and enjoy true 3D binaural sound on a headset or true 3D sound on multiple speakers. The user, for example, can have an experience similar to that of sitting in the front row, walking through the stage, sitting among the musicians, or being in a music hall surrounded by live instruments.")

- **Laitinen** at 3:39-61 ("Head-related transfer functions (HRTF) are transfer functions measured in an anechoic chamber with the sound source at the desired direction and the microphones inside the ears. There are a number of different ways to interpolate HRTFs. Creating interpolated HRTF filter pairs has been widely studied. For example, descriptions may be found in "Perceptual consequences of interpolating head-related transfer functions during spatial synthesis," by Elizabeth M. Wenzel and Scott H. Foster, in Proceedings of the IEEE Workshop on Applications of Signal Processing to Audio and Acoustics, New Paltz, N.Y., USA, pp. 102-105, October 1993; and "Interpolating between head-related transfer functions measured with low directional resolution," by Flemming Christensen, Henrik Møller, Pauli Minnaar, Jan Plogsties, and Søren Krarup Olesen, in Proceedings of the 107th AES Convention, New York, N.Y., USA, September 1999. For example, three HRTF pairs closest to the target direction may be selected from a HRTF database, and a weighted average of them may be computed separately for the left and the right ears. In addition, the corresponding impulse responses can be time-aligned before the averaging, and the inter-aural time differences (ITD) can be added after the averaging.")
- **Jerald** at 240 ("For more realistic audio and where auditory cues are especially important, auralization—the rendering of sound to simulate reflections and binaural differences between the ears—can be used. The result of auralization is spatialized audio—sound that is perceived to come from some location in 3D space (Section 8.2.2). Spatialized audio can be useful to serve as a wayfinding aid (Section 21.5), to provide cues of where other characters are located, and to give feedback of where the element of a user interface is located. A head-related transfer function (HRTF) is a spatial filter that describes how sound waves interact with the listener's body, most notably the outer ear, from a specific location. Ideally, HRTFs model a specific user's ears, but in practice a generic ear is modeled. Multiple HRTFs from different directions can be interpolated to create an HRTF from any direction relative to the ear. The HRTF can then modify a sound wave from a sound source, resulting in a realistic spatialized audio cue to the user.")
- **Jerauld** at 4:8-17 (In other examples, the provision of three-dimensional audio may be based on a head-related transfer function 'HRTF' and/or head-related impulse response


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HRIR' to create the illusion that Sound is originating from a particular location in 3D acoustic space. The HRTF describes how a given sound wave input is filtered by the diffraction and reflection properties of the head and pinna before the sound reaches the eardrum and inner ear. In other words, an HRTF. may be defined based on the difference between a sound in free air and the Sound as it arrives at the eardrum.")

- **Miller 722** at 13:17-33 ("According to another illustrative feature, the system 102 may use three-dimensional Sounds to announce the presence of some types of IOIs, such as some types of contextual IOIs. A three-dimensional sound refers to a sound that the user perceives as emanating from a particular location (or locations) within physical space. In reality, however, the audio information is presented to the user via the headset 108 and has no physical origin within the environment. As will be described below in Section D, the system 102 can achieve the above result through the use of Head-Related Transfer Functions (HRTFs), in conjunction with different types of wideband audio Sounds. In other implementations, the system 102 can use other techniques and technologies to create a three-dimensional audio effect (instead of HRTFs or in addition to HRTFs), such as Ambiophonics, Ambisonics, wave field synthesis etc."); *id* at 21:42-45 ("The Sound generation module 414 may create these sounds by transforming original Sound information using one or more Head-Related Transfer Functions (HRTFs)."); *id.* at 43:12-27 ("In one implementation, the Sound generation module 414 can produce a three-dimensional Sound using a library of Head-Related Transfer Functions (HRTFs), e.g., as provided in the data store 416. An HRTF models the anatomical features a person's face that have a person-specific bearing on the manner in which that person perceives the origin of Sound in his or her environment. To produce a three dimensional Sound, the Sound generation module 414 can choose an HRTF that is appropriate for a particular person, and for a particular sound location in space (relative to the person's location). The Sound generation module 414 can then apply that HRTF to modify a non-three-dimensional Sound (e.g., a flat or non-spatial Sound), to produce the three-dimensional Sound, e.g., by convolving the non-spatial sound with the chosen HRTF."); *id.* at 43:28-51 ("More specifically, in one case, the sound generation module 414 can receive input information which describes: (a) the non-three-dimensional sound to be played; (b) the location in space at which the sound is to be perceived as originating; and (c) (optionally) the identity of the user. The input information can describe the non-three-dimensional sound by providing reference information which identifies audio information in the data store 416, and/or may provide the audio information itself. For example, the non-three-dimensional sound may correspond to a telltale tone and/or a spoken message. Then, for each ear of the user, the sound generation module 414 can: (a) identify an HRTF associated with the location, for the particular user under consideration; and (b) apply the HRTF to the non-three-dimensional sound to produce the three-dimensional sound. The input information that is provided to the sound generation module 414 may originate from one or more of the other modules of the SI module 302 described below, e.g., corresponding to the path guidance module 420, the relevant information determination (RID) module 426, the exploration module 430, the orientation module 432, etc. The sound generation module 414 performs the above functions with respect to a library of HRTFs provided in a data store 416.")



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- **Begault 1992** at 5 ("The technique for implementing headphone localization involves creating a digital filter based on measurements of the head-related transfer function (HRIF). The HRTF can be thought of as frequency-dependent amplitude and time delay that result from the resonances of the pinnae and the ear canal and from the effects of head shadowing. These effects combine differentially as a function of sound source direction; hence, there is a frequency and group delay transfer function imposed on an incoming signal that is unique for any given source position. In other words, the spectrum of the HRTF alters the spectrum of the input signal in a spatially dependent way."), *id.* at 6 ("To implement HRTF processing for headphone sound, the spectrum of the incoming sound must be multiplied by the spectra of two HRTF measurements, one for each ear. This is accomplished digitally by the equivalent operation of time-domain convolution using two finite impulse response (FIR) filters (Oppenheim & Schafer, 1975)."), *id.* at Fig. 8 ("Basic method used by the Convolvotron; circuit shown for one sound source only. HT = head tracker; i = software for interpolating between four pairs of stored HRTF impulse responses.").
- **Sandgren** at [0009] ("In simulating an audio scene or creating a virtual audio scene, the sound sources' direct sounds are usually generated by filtering a monophonic sound source with two head-related transfer functions (HRTFs), one for each of left and right channels. These HRTFs, or filters, are usually determined from measurements made in an anechoic chamber, in which a loudspeaker is placed at different angles with respect to an artificial head, or a real person, having microphones in the ears. By measuring the transfer functions from the loudspeaker to the microphones, two filters are obtained that are unique for each particular angle of incidence. The HRTFs incorporate 3D audio cues that a listener would use to determine the position of the sound source."), [0047] ("The inventors have also recognized that suitable directional cues can be obtained by HRTF processing, i.e., filtering according to an HRTF, although such filtering is a computationally demanding task."), [0048]-[0049] ("In accordance with this invention, an HRTF-processed direct-sound signal is used for generating simulated early-reflection signals but is modified in order to approximate the spectral content of the early reflections. This results in enhanced externalization of virtual sound sources. Furthermore, by using cross-coupling in the early-reflection generator, a good approximation of reflections coming from the other side of the listener compared to the direct sound path can be achieved. This also results in a proper intensity balance between left and right channels of the early reflections and enables the same modification parameters to be used independently of the position(s) of the sound source(s). Thus, the modification parameters of the early-reflection generator can be held constant and one early-reflection generator can be used for multiple virtual sound sources. FIG. 5A is a block diagram of a sound-scene simulator 500 that includes HRTF filters Hl,0(z), Hr,0(z), an early-reflection generator 502, and two attenuation filters A0(z) 504, 506, one for each of left and right channels. The subscript/indicates the left channel, the subscript r indicates the right channel, and the subscript 0 indicates the direct sound. A monophonic signal from an input source is provided to an input of each of the HRTF filters Hl,0(z), Hr,0(z), and the outputs of the HRTF filters, which may be called the simulated direct-sound left- and right-channel signals, are provided to the early-reflection generator 502 and the attenuation filters 504, 506. The HRTF for the direct sound depends on only the incidence angle from the sound source to the listener.



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The outputs of the attenuation filters 504, 506 and the early-reflection generator 502 are combined by respective summers 508, 510 that produce left-channel and right-channel (stereophonic) output signals."), [0051]-[0058] ("FIG. 6A is a block diagram of a suitable early-reflection generator 502 that includes four adjustment filters, a left-direct filter Hll(z), a left-cross filter Hlr(z), a right-cross filter Hri(z), and a right-direct filter Hrr(z). The adjustment filters are cross-coupled as shown to modify the simulated direct-sound left- and right-channel signals from the HRTF filters Hl,0(z), Hr,0(z) (which enter on the left-hand side of the diagram) to simulate spectral content of early reflections. Left- and right-channel signals of the modified simulated direct sound are combined by respective summers 602, 604, and the generated simulated early-reflection signals exit on the right-hand side of the diagram …"), [0064] ("The method includes a step 702 of processing a direct-sound signal with at least one HRTF, thereby generating a simulated direct-sound signal."), [0082]-[0089] ("Reducing the lengths of the HRTFs is a first obvious simplification that has been used in prior simulators to decrease the number of computations required, but this also severely degrades the quality of the simulated early reverberation because the directional cues are decreased or even removed. Therefore, this is not further considered here. A second, better simplification is to assume that most reflections come from angles similar to the angle of the direct sound. In that case, the directional cues obtained when using the HRTFs for the direct sound can be reused and modified so that they approximate the directional cues of each reflection … "), [0090]-[0096] ("FIG. 9 shows the spectra of the left HRTFs for an angle of arrival of 25°, with the actual HRTF indicated by the solid line and the approximated HRTF indicated by the dashed line, and FIG. 10 shows the spectra of the right HRTFs for 25°, with the actual HRTF indicated by the solid line and the approximated HRTF indicated by the dashed line. The approximated HRTFs were obtained by scaling the HRTFs of the direct sound with the modification filters given by Eq. 19 … Hence, for reflections coming from the same side of the listener as the direct sound, the left HRTF of the direct sound should be used for the left HRTF of the reflection and the right HRTF of the direct sound should be used for the right HRTF of the reflection. For reflections coming from a side of the listener that is opposite to the direct sound, the left and right HRTFs should be switched when approximating the HRTFs of the reflection."), Figs. 4, 5A, 5B, 5C, 6A, 7A, 9, 10, 11, 12

- **Sauk 2007** at 2 ("To simulate the voices in a 3-D binaural environment around the listener, the computer must produce slightly different auditory localization cues through a digital filter customized for each ear [9]. The sound arriving at each eardrum undergoes multiple changes that provide the listener's brain with cues regarding the location of the sound source. Some of the changes are caused by the human torso, the head, the ear pinna, and the ear canal. Collectively, these changes are mathematically summed up into a Head Related Transfer Function (HRTF). The digital filter used to incorporate the HRTFs converts the 1-D monophonic sound into 3-D binaural sound [2], [5], [9], [10]. Research has been conducted to methodically examine the degree each localization cue has on the brain which allow humans to determine the exact location of the sound source [6], [10], [11]. The result of this research is an approximate digital filter that permits the listener to locate sounds emanating from different spatial locations to an accuracy of ±12 degrees [12]. Depending on how the computer adjusts the HRTFs, the listener can dynamically move about any sound environment of his



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choosing. A detailed mathematical explanation has been provided by Faller and Baumgarte along with the results and advantages of a multi-talker environment [2].”), *id.* at 6 (“When the system is turned on, an earcon will tell the listener to say ‘Yes’ when he hears the simulated sound coming from as far away as possible to maximize the accuracy of the binaural system. This step will cycle through several possible HRTFs to allow the listener to select the most distant virtual location to properly calibrate the system. In the next step, the earcon would tell the listener to face the direction of its simulated voice and say ‘Yes’. This step will calibrate the three gyroscopes in the headset so that the computer can record which direction the listener’s head is pointed for the selected HRTFs.”)

- **Schaefer** at 3:11-26 (“Recent work in human sound perception has yielded an understanding of how to generate directional sounds much more advanced than by simple binaural phase and amplitude manipulations. Especially relevant are Head Related Transfer Function (HRTF) filters that model the user's ears and surrounding anatomy. The “beacon” sound from the target direction of interest can be fed through HRTF filters to produce realistic stereophonic sounds. Review of literature suggests a head-pointing accuracy on the order of 5 to 10 degrees would be available from this technique, but this may be too large for very limited peripheral fields. Additionally, the technique requires the user to wear stereo headphones, which may be inconvenient or dangerous in some situations, and many people have trouble disambiguating HRTF-generated sounds from the front and rear.”); *id.* at 13:6-13 (“One audio feedback embodiment uses the relative angle of the target direction compared to the user's current gaze direction, then a stereo sound is synthesized that appears to come from the direction of the desired target, using techniques such as the Head-related Transfer Function (HRTF) that are known in the art. The accuracy of this approach is limited by how acutely the user can identify the apparent angle of the sound.”)
- **Tokubo** at 29:48-65 (“One example of a sound localization function is a Head-Related Transfer Function (HRTF), which is a response that characterizes how an ear receives a sound from a point in space. A pair of HRTFs for the ears may be utilized to synthesize a binaural sound that seems to come from a particular point in space. The HRTF can also be described as the modifications to a sound from a direction in free air to the sound arriving at the eardrum. These modifications include the shape of the listener's outer ear, the shape of the listener's head and body, the acoustical characteristics of the space in which the sound is played, and so on. All these characteristics influence how a listener can accurately tell what direction a sound is coming from. Due to the physical differences of each person, each person has a different HRTF. Implementations of the invention for sound localization are described using HRTF, but any other form of sound localization that accounts for the physical characteristics of a listener can be utilized with implementations of the invention.”), *id.* at 33:6-32 (“The sound localization algorithm uses the HRTF of the user, as well as the current location of the user's ears to generate the localized sound for the earphones. The acoustic signals for the localized sound, which are played by the earphones, provide an acoustic clue to the user regarding the virtual location in space of the virtual object. In one implementation, the acoustic signals for the localized sounds are delivered with a higher volume when the object or person originating the sound is shown on the display



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of the HMD 102, or in the display 207 (e.g. a shared/social screen) connected to game console 106. The HMD is acting, in a sense, also as a directional microphone. When the sound origin is not on the HMD's display, the volume of the sound is lower. Because the HMD is working as a directional microphone, the user has an acoustic cue to the whereabouts of the origin of the sound as the user moves the HMD. Remote player 1806 b is assigned a position in the physical space of player 100. Sound localization includes generating sounds that appear to come from player 1806 b or from portable device 1808 b. For example, when player 1806 b speaks, the speech is captured by portable device 1808 b and then transmitted to game console 106. The speech from user 1806 b is then transformed using HRTF, or some other sound localization algorithm, to deliver the speech to user 100 as if player 1806 b were standing near player 100 as indicated in the illustrated virtual scene."), *id.* at 34:12-29 ("FIG. 20 illustrates a method for selecting a sound localization function based on the user perception of the sound received, in accordance with implementations of the disclosure. Virtual surround through headphones works best with an accurate measurement of the person's HRTF (or some other sound localization function). The process to measure HRTF is difficult (i.e., the process requires putting small microphones in the person's ear, and sitting perfectly straight while a speaker is moved all around the head at various positions and distances). Implementations of the invention utilize a database of measured HRTFs for a population of users. In one implementation, a motion controller is utilized to create a sound localization function for the user that is based on one or more HRTFs from the database. The HRTF for the user is not actually measured, but by finding one or more HRTFs that "work" for the user, a realistic virtual surround system with localized sound delivery is provided.")

- **Sauk 903** at 8:7-33 ("Referring again to FIG. 5, it can be observed that the head-tracking apparatus 102 provides information regarding the head rotation and position of the listener. The head tracking information is used by the sound environment manager 494 to alter the various audio filters within the audio generator 496 applied to enunciated data 602 received by the RF Receiver 492. In order to advantageously present one or more binaural environments to each user, the BSS 400 includes an audio generator 496. The audio generator 496 processes enunciated data as necessary to implement the various audio environments selected by a user. In this regard, the audio generator 496 includes digital signal processing circuitry for audio generation of enunciated data. For example, each word or sound specified by the enunciated data can require a specific set of HRTF filters 408, a set of binaural room impulse response (BRIR) filters 410, and a set of reverberation filters 412. All of these sets are then combined as necessary in the audio mixer 484. The resulting audio signal from the audio mixer 484 is communicated to the headset 108. The result is an audio signal for the left speaker 106 that may be a combination of monophonic, stereophonic, and binaural sound representing one or more sound sources as specified by the enunciated data 602 and the metadata 604. The audio signal for the right speaker 104 can similarly be a combination of monophonic, stereophonic, and binaural sound representing a combination of different sounds as specified by the enunciated data 602."), *id.* at 1:66-2:13 ("Conventional binaural systems have been proposed which simulate some of these changes that occur to sound as it arrives at the human ear from a remote source. Some of these systems are directed toward improving the filtering performance of the



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HRTF. The term "filter" as used herein refers to devices which perform an operation equivalent to convolving a time-domain signal with an impulse response. Similarly, the term "filtering" and the like as used here refer to processes which apply such a filter to a time-domain signal. Considerable computational resources are required to implement accurate HRTFs because they are very complex functions of direction and frequency. The overall design of the binaural audio system is very important to reduce implementation costs, improve sound feed-back rates, and to implement practical binaural sound fields which may include many sound sources.")

- **Furse** at 8:29-34 ("Abstract spatial audio streams can be converted to stereo suitable for headphones using HRTF (Head-Related Transfer Function) data. Here filters will typically be reasonably complex as the resulting frequency content is dependent on the direction of the underlying sound sources."), *id.* at 14:66-15-17 ("As an example of frequency-domain tinting, we consider the case where $h(\theta,\varphi)$ is used to represent HRTF data. Important cues that enable a listener to sense the direction of a sound source include Interaural Time Difference (ITD), that is the time difference between a sound arriving at the left ear and arriving at the right ear, and Interaural Intensity Difference (IID), that is the difference in sound intensity at the left and right ears. ITD and IID effects are caused by the physical separation of the ears and the effects that the human head has on an incident sound wave. HRTFs typically are used to model these effects by way of filters that emulate the effect of the human head on an incident sound wave, to produce audio streams for the left and right ears, particularly via headphones, thereby given an improved sense of the direction of the sound source for the listener, particularly in terms of the elevation of the sound source. However prior art methods do not modify a spatial audio stream to include such data; in prior art methods, the modification is made to a decoded signal at the point of reproduction."), *id.* at 18:1-13 ("FIG. 5 shows tinting being applied to a spatial audio stream before being converted for use with headphones. A sound file player 502 passes spatial audio data to a periphonic HRTF tinting component 504, which performs HRTF tinting according to one of the techniques described above, resulting in a spatial audio stream with enhanced IID cues. This enhanced spatial audio stream is then passed to a stereo converter 506, which may further introduce ITD cues and reduce the spatial audio stream to stereo, using a simple stereo head model. This is then passed to a digital to analogue converter 508, and output to headphones 510 for playback to the listener. The components described here with reference to FIG. 5 may be software or hardware components.")
- **Zhou** at 1044-45 ("Exact spatial 3D sound in virtual and augmented environments requires perceptual externalization of the sound source, which can only be brought about by using head related transfer functions (HRTFs) (Bill and Keith, 1994) (these are tuned to each individual), reflections, reverberation, etc. (Wenzel, 1994) which might be too complex to be included in normal real time AR applications (which need to be a real time interactive system for any user without individual training). An alternative way to generate 3D sound is to use open source software development kits (SDKs), which have already incorporated the general HRTFs database and simple model of environment to generate 3D sound. The minimum requirement of these SDKs to generate 3D sound is to update the relative position of the virtual sound source to the head coordinate system. Thus, with such sound sources, a problem turns to be how can



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we track the sound source relative to user's head coordinate system."), *id.* at 1046 ("Generating real 3D sound requires perceptual externalization of the sound source, which can only be brought about by using HRTFs (Bill and Keith, 1994), reflections, reverberation, etc. (Wenzel, 1994). These HRTFs can be used to produce 3D sound effects from a linear convolution between sound signals and its corresponding spatial-related impulse response (Wenzel et al., 1988) while the reflections and reverberations involve sophisticated modeling of environment. The individually derived HRTFs are better for individual users to provide more realistic sound experience. However, individual HRTFs are difficult for AR implementation due to the fact that AR systems are designed to be realtime interactive systems that do not need individual user configuration. Thus, our experiments were taken for randomized selected students. For easy implementation of 3D sound generation, several open source SDKs, have been developed such as OpenAL (Loki Entertainment Software) and FMOD (Firelight Technologies). These use the general HRTFs database and modeling environment in a relative simple manner. However, as mentioned in Section 1, for AR systems 3D sound does not play a significant role to tell the depth (or the distance of the frontal sound sources) because most of actual AR spaces are relatively of small size (for example small offices).")

- **Jin** at 308 ("In virtual reality applications, sound sources are often presented over headphones to give precise control over the virtual auditory environment. Head-related transfer functions (HRTFs) are used to create virtual auditory space and have commonly been recorded on humans and manikins to allow externalization and spatialisation of sound sources presented in a binaural audio display. An HRTF is an acoustic transfer function that describes the sound pressure transformation from a location in the free-field to the listener's eardrum [4]. HRTFs contain the acoustic cues necessary for spatial hearing: the interaural time difference cue (ITD), the interaural level difference cue (ILD) and the spectral transformations applied by the outer ear. More details about the acoustic cues for spatial hearing can be found in [5]."), *id.* ("Head-orientation sensors have also been used with binaural audio systems to heighten the experience of the user by allowing head movement. However, head movement increases the complexity of the audio rendering engine as it has to present sound sources in the correct locations relative to the user's head orientation. In current real-time, head-tracked 3D audio systems there is a trade off between keeping the system running in realtime and increasing the number of simultaneous sound sources that are rendered spatially. In one extreme, the number of simultaneous sound sources is limited and the HRTF filtering for spatialisation is performed on-the-fly. At the other extreme, the number of simultaneous sound sources can be unlimited, but the HRTF filtering is performed offline with no head-tracking during playback. Hence the real conflict is between real-time head-tracking and the number of simultaneous sound sources. Dedicated hardware can be used to achieve 3D audio with headtracking, but this can turn out to be costly, e.g., Lake Technology's Huron processor uses one DSP chip per sound source [6]. This paper presents a method that has been incorporated into a 3D audio playback engine (3DApe) that runs on standard PC hardware and allows real-time headtracking to be maintained with an unlimited number of simultaneous sound sources")



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- **Jang** at 1:46-56 ("According to a sound processing method in the virtual reality system as described above, it is possible to make a change in the sound by modeling the path and change of sound according to relative locations of a sound-generating object, locations of surrounding things, and direction of sound propagation, to give the sense of reality to the sound. Further, to express direction of sound in view of the listener, may be modeled by using a sound processing technique, such as a Head Related Transfer Function (HRTF), so as to determine the output sound.")
- **Ek** at 19:25-29 ("In emulating sounds from different positions within virtual/physical 3D audio space, mobile communication device 204 may perform additional signal processing, such as, for example, applying a head-related transfer function (HRTF) to the audio portion of the AV data, depending on the location of the object in the user's field of vision.")
- **Assenmacher** at 131-132 ("Filtering a sound source with an appropriate HRTF pair in order to obtain a synthetic binaural signal is called Binaural Synthesis. The synthesised signal contains the direction information of the source which is provided in the HRTFs. In other words, the binaural synthesis transforms a signal without position information into a signal representing the sound pressure at the ears of a listener from a virtual source located at the point defined by the HRTF. Reproducing the resulting signal over a dynamic cross-talk cancellation system should enable us to create the illusion of sound emanating from any direction in 3D space. Superposition allows us to extend the process in order to generate N different sources at different positions. The resulting signal is again binaural. In a video virtual reality system the position of any object which can be rendered with a sound, too, is given by the scene graph in a world coordinate system. To choose the right HRTF from the database, only the relative position to the user has to be calculated. When the listener moves his head, he changes the relative position, which is provided by changing the used HRTF, so that he is able to locate the virtual source every time at a fixed position in the world coordinate system. Furthermore, moving sources are also possible.")
- **Lentz** at 6 ("At the end of every filter pass, which represents, up to now, a mono signal, an HRTF has to be used to generate a binaural head-related signal which contains all directional information. All HRTFs used by the VirKopf system were measured with the artificial head of the ITA for the full sphere due to the asymmetrical pinnae and head geometry. Nonsymmetrical pinnae lead to positive effects on the perceived externalization of the generated virtual sources [43]. A strong impulse component such as the direct sound carries the most important spatial information of a source in a room. In order to provide a better resolution, even at low frequencies, an HRTF of a higher resolution is used for the direct sound. The FIR filter length is chosen to be 512 taps. Due to the fact that the filter processing is done in the frequency domain, the filter is represented by 257 complex frequency domain values corresponding to a linear resolution of 86 Hz. Furthermore, the database does not only contain HRTFs measured at one specific distance but, also near-field HRTFs. This provides the possibility of simulating near-to-head sources in a natural way. Tests showed that the increasing interaural level difference (ILD) becomes audible at a distance of 1.5m or closer to the head.")



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- **Ortega-Gonzalez** at 3 ("There are different techniques for modeling different aspects of the human hearing phenomenon. Among them, we can mention the followings: the subtle differences on perceived sound for both ears (i.e. Inter-Aural Intensity and Time Differences -IID and ITD-), the effect of human body and human listening system (i.e. Head-Related Transfer Functions -HRTF- filtering) and the environmental acoustics (i.e. reverberating and early reflections). The HRTF is the most used technique for realistic 3D spatialization. The objective of an HRTF is to recreate the natural altering effect on listened sounds caused by the morphology of each pinnae as well as by the diffraction and reflection effects due to the head and shoulders respectively. Begault [12] stated that HRTF represents the spectral filtering which occurs before the arrival of the sound to the internal ear drum. These effects vary from individual to individual forcing systems designers to choose between the use of individualized or generalized filters. For implementing the approach presented in this paper we employed the generalized HRTF database compiled by Bill Gardner et. al. [13]. The use of HRTF in VR applications normally requires a series of online processes. In typical 3D sound systems when a sound source is positioned, the HRTF filter corresponding to the orientation of the virtual source is loaded and applied continuously to the sound wave.")
- **Tanaka** at 3:37-44 ("Moreover, another aspect of such an apparatus resides in that data for a sound image localization processing by the convolvers is supplied as data for a time-base impulse response (IR). Thereby, an HRTF (thus, head-related transfer characteristics) can be accurately approximated without deteriorating the sound image localization and the size of a circuit (thus, the number of coefficients of the convolvers) can be even smaller."), *id.* at 14:4-20 ("Further, the practical configuration of each of the convolvers 1 and 2 will be described hereinbelow. Namely, the convolvers 1 and 2 are implemented by using, for example, digital signal processor (DSP) or the like as filters of the asymmetrical finite impulse response (FIR) type in which a RAM for storing convolution operation coefficients. The coefficients supplied by the control means 4 are temporarily stored in the buffers 12 and 13. Then, the coefficients stored therein are read by the convolvers 1 and 2. The control means 4 confirms from signals received from the buffers 12 and 13 that the coefficients stored in the buffers 12 and 13 are read by the convolvers 1 and 2. Subsequently, the control means 4 writes the next group of the coefficients to the buffers 12 and 13. Thus, the control means 4 can perform efficiently not only the operation of supplying the coefficients but also other operations by utilizing the buffers 12 and 13.")
- **Mukojima** at 1:14-32 ("In a three-dimensional virtual reality system for example, a sound image positioning apparatus is conventionally used as a means for enhancing presence of virtual reality experience. In such a system, a cubic sound field is generated by creating direction perspective and distance perspective in auditory sensation by producing audio signals from a monaural sound source through a plurality of channels having time difference, amplitude difference, and frequency characteristic difference based on binaural technique. To be more specific, an input audio signal is attenuated in a particular frequency component by a notch filter, for example, to create elevation. The input audio signal is also converted by a delay circuit into left channel and right channel signals having a time difference, and is further given acoustic transfer characteristic from a virtual sound source by a FIR (Finite Impulse Response) filter. A



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parameter of the FIR filter is given from an HRTF database storing head-related transfer functions (HRTF) measured with using a dummy head in advance.")

- **Flaks 968** at 12:5-40 ("When suitable data is collected, the process 700 goes on to step 710 to determine a HRTF for the user 8 in step 710. In some embodiments, there is a library of HRTFs from which to select. These HRTFs may be associated to various physical characteristics of users. Examples include, but are not limited to, head size and width, pinna characteristics, body size. For example, a specific HRTF may be associated with specific measurements related to head size and pinna. The measurements might be a range or a single value. For example, one measurement might be head width, which could be expressed in terms of a single value or a range. The system may then select an HRTF for the user by matching the user's physical characteristics to the physical characteristics associated with the HRTFs in the library. Any technique may be used to determine a best match. In one embodiment, the system interpolates to determine the HRTF for the user. For example, the user's measurements may be between the measurements for two HRTFs, in which case the HRTF for the user may be determined by interpolating the parameters for the two HRTFs. Next, the system may perform additional steps to verify that this HRTF determination is good, and perhaps select a better HRTF for this listener. In step 712, the system plays a 3D audio signal for the user. This may be played through a headset being worn by the user. The user may be asked to point to the apparent source of the 3D audio signal, in step 714. In one embodiment, the process is made into a game where the user is asked to shoot at the sound. For example, the system plays a duck sound without any visuals. In step 716, the system determines the location to which the user is pointing. Step 716 may include using the depth camera system to collect depth information. The system might also ask the user for voice input, which the system could recognize using speech recognition. Steps 712-716 may be repeated for other sounds, until it is determined in step 717 that sufficient data is collected.")
- **Osman** at 5:18-28 ("Different people have different HRTF's, and the most compelling experience is delivered when that HRTF of the user is utilized. In one embodiment, a standard HRTF is utilized when the HRTF for the user is not available. The standard HRTF takes into account the average characteristics of a human being. Although the HRTF of the user is not utilized, the standard HRTF can still provide a realistic experience for the user. In addition, calibration methods can be utilized to further customize the sound localization experience for the particular user to develop an HRTF for the user."), *id.* at 14:29-45 ("FIG. 9A illustrates a method for selecting a sound localization function based on the user perception of the sound received, according to one embodiment. Virtual surround through headphones works best with an accurate measurement of the person's HRTF (or some other sound localization function). The process to measure HRTF is difficult (i.e., the process requires putting small microphones in the person's ear, and sitting perfectly straight while a speaker is moved all around the head at various positions and distances). Embodiments of the invention utilize a database of measured HRTFs for a population of users. In one embodiment, a motion controller is utilized to create a sound localization function for the user that is based on one or more HRTF's from the database. The HRTF for the user is not actually measured, but by finding one or more HRTFs that "work" for the user, a realistic virtual



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surround system with localized sound delivery is provided."), 4:14-67 ("A sound localization function *f* (also known herein as a sound function, a localization function, and sometimes plainly as a "function") is a function or algorithm that generates a localized sound based on a sound and the location in space perceived as the origin of the sound. … One example of a sound localization function is a Head-Related Transfer Function (HRTF), which is a response that characterizes how an ear receives a sound from a point in space. A pair of HRTFs for the ears may be utilized to synthesize a binaural sound that seems to come from a particular point in space."), 12:14-27 ("Computing device 712 includes a processor 732, which is coupled to memory 734, to permanent storage device 758, and to other modules inside, or connected to, computing device 712. Sound localization computer program 736 resides in memory 734, but can also reside in permanent storage device 758."), 13:10-18 ("Database 710 includes a plurality of sound localization functions associated with a plurality of different users. In one embodiment, the sound localization functions are the measured HRTF functions obtained for a plurality of users, but other sound localization functions can also be utilized."), 14:29-50 ("The HRTF for the user is not actually measured, but by finding one or more HRTFs that "work" for the user, a realistic virtual surround system with localized sound delivery is provided. It is not practical to have a sound localization function for millions of users. Embodiments of the invention utilize the measured sound localization functions for a representative segment of people, and then tests are performed to select one of these functions for a particular user".), 14:51-19:36 (describing various calibration methods by which an HRTF may be selected, or in some instances calculated, for a given user), 18:11-18 ("In one embodiment, the sound localization function for a user is stored in a server on the network, which is accessible by many devices. The sound localization function can then be shared with other devices, in order to deliver sound localization in other devices. For example, the user may use a game console to calculate the function, and then sound localization can be provided to the user when the user is wearing headsets connected to a portable device."), 18:62-67 ("In operation 1114, the sound localization function is calculated for the user. See for example the embodiments described above with reference to FIGS. 9A-9B and 10A-10B. Further, in operation 1116, the calculated sound localization function is stored in a database so other devices can use the function for localizing sound to this user."), Figs. 7, 9A-9B, 10A-10B, 11-12

- **Vorlander** at 416 ("A mono source signal, properly characterized and calibrated according to well defined specifications (see below), can be processed in such a way that its perceptual cues are amended by a spatial component. A stereo or surround setup is capable of creating an effect of virtual sources which can produce an appropriate spatial effect [1]. A binaural mixing console can be used for processing headphone or loudspeaker signals by using head-related transfer functions, HRTF [4].With a database of HRTF or the corresponding head-related impulse responses, HRIR, any direction of sound incidence can be simulated, when a mono source s(t) is convolved with a pair of head-related impulse responses.")
- **Cho** at [0043] ("According to the embodiments of the present invention, when an audio signal which is set to be output directionally is output, the HMD 100 can output the audio signal based on location information of an external digital device corresponding



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to the audio signal. According to the embodiments of the present invention, the HMD 100 can convert an audio signal into a 3-dimensional (3D) audio signal based on detected location information of an external digital device, and output the 3D audio signal. Here, the 3D audio signal is a binaural audio signal having 3D effect. More specifically, the HMD 100 can generate HRTF (Head Related Transfer Function) information based on location information of an external digital device, and convert an audio signal of the external digital device into a 3D audio signal using the generated HRTF information. HRTF refers to a transfer function between a sound wave generated from a sound source located at an arbitrary position and a sound wave arriving at the tympanic membrane of an ear, and has a value depending on orientation and altitude information of the sound source. When an audio signal without directionality is filtered with an HRTF in a specific direction, a person feels as if he listens a sound from the specific direction when listening to the audio signal. Accordingly, the user 10 wearing the HMD 100 can feel as if he/she listens the audio signal 'Device a' of the external digital device 200a and the audio signal 'Device b' of the external digital device 200b from the direction in which the external digital devices 200a and 200b are located respectively.")

- **Wan** at 1 ("The 3D audio space is readily achieved through stereo headphones and head related transfer functions (HRTFs).")
- **Algazi 2011** at 35 ("Fortunately, at typical sound pressure levels and object velocities, the physical processes are essentially linear and time invariant, and linear systems theory applies. The effects of the listener's own body on sounds coming from an isotropic point source in an anechoic environment are captured by the so-called HRTF [20], [21]. The HRTF is defined as the ratio of the Fourier transform of the sound pressure developed at the ear to the Fourier transform of the sound pressure developed at the location of the center of the listener's head with the listener absent. This frequency-domain definition has the advantage that the resulting HRTF is essentially independent of range when the source is in the far field. Most HRTF measurements are made under these conditions. The far-field range dependence is easily obtained merely by adding the propagation delay and the inverse range dependence.

  The inverse Fourier transform of the HRTF is the head-related impulse response (HRIR). If h1 t 2 is the head-related impulse response for a distant source and c is the speed of sound, then the anechoic pressure response to an impulsive velocity source at a distance r is proportional to h1 t2r/c2 /r. The situation is more complicated when the source has a complicated radiation pattern or is distributed or is close to the head [16], and we limit our discussion to an isotropic point source in the far-field.")
- **Algazi 2001** at 99 ("Head-related transfer functions (HRTFs) capture the sound localization cues created by the scattering of incident sound waves by the body, and play a central role in spatial audio systems. Most HRTF-based commercial systems convolve the input signal with a single, "standard" head-related impulse response (HRIR), and several studies have employed the public-domain dataset for the KEMAR mannequin [1]. … The CIPIC Interface Laboratory at U.C. Davis has measured HRTFs at high spatial resolution for more than 90 subjects. Release 1.0 — a public-domain subset for 45 subjects (including KEMAR with large and with small pinnae) — is available by downloading from our web site (http:// interface.cipic.ucdavis.edu). In



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addition to including impulse responses for 1250 directions for each ear of each subject, the database includes a set of anthropometric measurements that can be used for scaling studies. This paper describes the content of the database, and briefly describes the characteristics of the data. … All HRTFs were measured with the subject seated at the center of a 1-m radius hoop whose axis was aligned with the subject's interaural axis. The position of the subject's head was not constrained, but the subject could monitor his or her head position [7]. … Sound source location was specified by the azimuth angle ; and elevation angle < in interaural-polar coordinates."); *id*. at 100 ("Although the exact HRTF is complicated, its general behavior can be estimated from fairly simple geometric models of the torso, head and pinnae [8, 9, 10]. These models can be individualized to particular listeners if appropriate anthropometric measurements are available [11]. However, specifying a general set of welldefined and relevant measurements is problematic. The problem is particularly difficult for the pinna, where small variations can produce large changes in the HRTF. Anthropometric measurements, even if imperfect, enable the investigation of possible correspondences or correlations between physical dimensions and HRTF features."); id. at 102 ("High-spatial-resolution HRTF measurements clarify the physical sources of HRTF behavior. A uniform database of HRTFs enables the study of person-to-person differences and of the relation of temporal and spectral characteristics of the HRTF to the anthropometric data. We hope that public availability of the CIPIC HRTF database, augmented with anthropometric measurements, will facilitate further research in the understanding, modeling, and use of individualized HRTFs.")

- **Romblom** at Abstract ("It is difficult to present near-field virtual audio displays using available HRTF filters, as most existing databases are measured at a single distance in the far-field of the listener's head. Measuring near-field data is possible, but would quickly become tiresome due to the large number of distances required to simulate sources moving close to the head. For applications requiring a convincing near-field virtual audio display, one could compensate the far-field HRTF filters with a scheme based on 1/r spreading roll off. However, this would not account for spectral differences that occur in the near-field. Using difference filters based on a spherical head model [1][2][3], as well as a geometrically accurate HRTF lookup scheme [4], one can compensate existing measured data and present a convincing virtual audio display for near-field distances."); *id*. at 1-2 ("When binaural synthesis is chosen to simulate 3D sound sources over headphones, the Head-Related Transfer Functions (HRTF) used have most often been measured at a single distance in the far-field of the listener. Unfortunately, including a variety of near-field distances would substantially increase the required number of physical measurements. To avoid this cumbersome procedure, it is possible to compensate the existing data using the well known law of '1/r spreading roll off' [5], effectively turning up the volume as you approach the head. However, this does not account for the significant frequency-dependent increase of interaural level difference (ILD) at close distances [1]. It also does not account for near-field geometric error: as a source moves closer to the head, the angle from the ear to the source can differ greatly from the commonly used angle from head-center to the source [4]. In this paper, we investigate two complementary methods for simulating near-field sources using common far-field HRTFs. The first approach, extending the work of Duda et al., derives a "difference filter" that compensates for spectral differences between far-field



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and near-field sources. The second approach, referred to as the "cross-ear model", implements an HRTF lookup scheme that relies on the vector from the ear to the source to select the correct HRTF position, rather than on the more commonly used vector from headcenter to source. In addition, it modifies the delays and gains based on geometry, with consideration given to preserving the time it takes for sound to diffract around the head. The two approaches can be used in conjunction to provide more convincing positioning and coloration of near-field sources."); *id*. at 3 ("Our model is an extension of conventional HRTF processing based on far-field HRTFs. Such systems typically employ a grid of HRTFs measured at a single distance and a variety of azimuths and elevations. HRTF measurements are often long and cumbersome. The approach described below relies on a 'difference filter' that predicts the spectral differences between a source located in the near-field of the listener and a source located at a corresponding direction in the farfield. Figure 4 – A near-field source S and a measured farfield source A. We wish to simulate source S. HRTFs are measured on the perimeter of the shaded region. Figure 4 can help provide an intuitive grasp of the proposed scheme. We are interested in the HRTF for a source S located in the near-field of the head. We have a measured HRTF at point A in the far-field. The difference filter is derived using the HRTF predicted by the sphere model for both the near-field source S and far-field source A: Difference Filter (f) = HRTF model, near-field / HRTF model, far-field. This difference filter is applied in series with the farfield HRTF measured at point A in order to approximate the near-field HRTF of that same head: HRTF approximated, near-field ≈ Difference Filter (f) x HRTF measured, far-field. The assumption made is that the spectral differences observed in a spherical head model between near-field and far-field sources are similar to those of measured heads. Such an assumption is in good agreement with the results presented by Duda [1]. The difference filter approximates the spectral changes between the nearfield and the far-field, while the measured HRTF contains the unique features of the head, torso and pinna."); *id*. at 4-5 ("In 1999, Brungart showed a systematic mapping between near-field and far-field HRTFs that depends upon the distance and orientation of a source relative to the head. In a head-centered near-field approach, one effectively looks up the wrong HRTF filter. By looking up individual HRTF filters using the vector from the ear to the source we are able to find the most appropriate far-field HRTF. 3.2. Cross-ear vs. Head-Center HRTF lookup The cross-ear model attempts to preserve a source's angle of arrival at the ear. HRTFs are typically measured at one constant distance from the listener and the resulting data grid traces an "HRTF sphere" of radius r around this listener. Figure 5 shows a source at location S positioned exactly at a distance r from the listener. The vector CS (head-center to source) is typically used to index the HRTF at location S. Filters for both the left and right ears are looked up with this information. It should be noted, however, that the actual direction from the left ear L to the source S is LS. The actual direction from the right ear R to the source S is RS. If the angle of CS is held constant while its length is increased, that is, if source S is moved away from the head, the directional changes to LS and RS are minimal. For this reason, using CS to index an HRTF is an acceptable approximation in the far-field. This is not the case for near-field sources. Figure 5 - Sound source on the HRTF sphere Consider the geometry depicted in Figure 6 where the source moves radially toward head-center C. The point A represents the extension of vector CS (head-center to



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source) at the intersection with the HRTF sphere. If CA is employed to lookup the HRTF, the directional error can become great – the vector LA (left ear to measurement radius) differs considerably from LS (left ear to source.) The same is true of the vectors RA and RS, and the error will become greater as sources become closer. Figure 6 – A sound source inside the HRTF sphere, farfield model A geometrically correct HRTF can be found if the left and right ears use filters from different locations on the HRTF sphere. In Figure 7, the line LS (left ear to source) intersects the HRTF sphere at the point AL. The HRTF measured at AL contains a much more accurate approximation of the spatial information that the left ear would impart upon a near-field source S. For systems using head-centered HRTF indexing, the vector CAL (head-center to left ear – extended to measurement radius) points to the correct HRTF. An identical argument applies to the right ear. Figure 7 - Sound source at a distance within the HRTF measurement radius. It is interesting to note that this model gives a more accurate directional approximation for sources beyond the HRTF sphere as well, as shown in Figure 8. The direction LA differs from the desired direction LS, again the application of the same algorithm determines the most appropriate HRTF direction (Figure 9).")

- **Zhang** at Abstract ("This paper studies head-related transfer function _HRTF_ sampling and synthesis in a three-dimensional auditory scene based on a general modal decomposition of the HRTF in all frequency-range-angle domains. The main finding is that the HRTF decomposition with the derived spatial basis function modes can be well approximated by a finite number, which is defined as the spatial dimensionality of the HRTF. The dimensionality determines the minimum number of parameters to represent the HRTF corresponding to all directions and also the required spatial resolution in HRTF measurement. The general model is further developed to a continuous HRTF representation, in which the normalized spatial modes can achieve HRTF near-field and far-field representations in one formulation. The remaining HRTF spectral components are compactly represented using a Fourier spherical Bessel series, where the aim is to generate the HRTF with much higher spectral resolution in fewer parameters from typical measurements, which usually have limited spectral resolution constrained by sampling conditions. A low-computation algorithm is developed to obtain the model coefficients from the existing measurements. The HRTF synthesis using the proposed model is validated by three sets of data: _i_ synthetic HRTFs from the spherical head model, _ii_ the MIT KEMAR _Knowles Electronics Mannequin for Acoustics Research_ data, and _iii_ 45-subject CIPIC HRTF measurements."); *id*. at 2348 ("In Sec. III, we further develop the general HRTF model to a continuous representation. We apply normalized spatial modes to achieve near-field and far-field HRTF representations in one formulation, which provides a way to obtain the range dependence of the HRTF from measurements conducted at only a single range. We study the radially invariant HRTF spectral components and find that the HRTF spectrum has an underlying pattern similar to the spherical Bessel functions. We use an orthogonal property of the Bessel functions to form frequency basis functions, Fourier spherical Bessel (FSB) series, to model the HRTF spectral components. Besides achieving much higher spectral resolution, this series representation can has far few parameters compared to the measurements for a more efficient HRTF representation."); *id*. ("Section V validates the developed HRTF sampling theory and the proposed HRTF continuous representation by decomposing the experimentally



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measured[15, 16] (or analytically simulated) HRTFs on a single sphere and synthesizing HRTFs at any frequency for an arbitrary spatial location to check both reconstruction and interpolation performances."); *id*. at 2354 ("SIMULATION RESULTS A. HRTF database Three sets of HRTF database are used. (1) Analytically simulated HRTF from the spherical head model.17 The HRTF for an ideal rigid sphere is defined as the pressure on the sphere at the defined ear position divided by the pressure that would exist at the sphere center in the absence of the sphere. The synthetic data are without noise influence and provide reliable reference to check the proposed sampling theory and the continuous model performance. (2) The HRTF database for KEMAR from the MIT media laboratory.15 KEMAR is designed according to the mean anatomical size of the population; thus results from KEMAR HRTF represent the mean performance. The measurements are the head-related impulse responses in the time domain at 44.1 kHz sampling rate and each response is 512 samples long, from which a 512-tap HRTF can be obtained by the discrete-time Fourier transform. The speakers were at a distance of 1.4 m away from the head center. The HRIRs (or HRTFs) were sampled in the equidistance in the azimuth arc, where the measurements are available for elevation steps of 10° ranging from 0° (north pole) to 130° (40° underneath the horizontal plane) and for full azimuth cover but have a decline of azimuthal resolution toward the pole, as shown in Table I. (3) HRTF database of human subjects from CIPIC interface laboratory.16 The HRIR measurements performed at CIPIC include 45 subjects. A 200 samples long pseudorandom signal generated by the snapshot system (sampling frequency is 44.1 kHz) is used as the test signal. For each subject, the HRTFs are measured at 1250 points on the sphere of 1 m away from the listener. The elevation varies uniformly from 0° to 135° in the step of 5.625°; and there are 50 azimuth samples at each elevation but not uniformly sampled; i.e., $\varphi$ = [0:5:45,55,65,80,100,115,125,135:5:225,235,245,260, 280, 295,305,315:5:355]°. The samplings are more dense near the median plane but very coarse near the ear where the azimuth varies in the step of 20°.")

- **Brungart** at Abstract ("Researchers have long recognized that the binaural difference cues that dominate auditory localization are independent of distance beyond 1 m but change systematically with distance when source the approaches within 1 m of the listener's head. More recent research has shown that listeners are able to use these binaural cues to determine the distances of nearby sound sources. However, technical challenges in the collection and processing of near-field Head-Related Transfer Functions (HRTFs) have thus far prevented the construction of a near-field audio display. This paper summarizes the current state of research in the localization of nearby sound sources, and outlines the technical challenges involved in the creation of a near-field virtual audio display."); *id*. at 1 ("Over the past 15 years, virtual audio displays have matured from crude laboratory prototypes into sophisticated head-coupled systems capable of manipulating the perceived azimuth and, to a lesser extent, the perceived elevation of virtual sound sources. However, the current generation of virtual audio displays cannot generate realistic virtual sounds in the "near field" within 1 m of the head."); *id*. at 2 ("Fig. 1. Head-Related Transfer Functions (HRTFs) for a sound source directly to the left of the listener (90 ) measured at three distances (1.0 m, 0.25 m, and 0.12 m) from the center of the head. The HRTFs were measured with a Knowles Electronics Manikin for Acoustic Research (KEMAR) and an acoustic point



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source, and have been normalized by the free-field sound pressure at the center of the head to eliminate the overall effects of distance (Brungart and Rabinowitz, 1999). Note that, as the sound source approaches the head, the magnitude of the HRTF increases rapidly at the ipsilateral ear and decreases slightly at the contralateral ear. This results in a large increase in ILD (the difference between the solid and dotted lines) across all frequencies for nearby sources."); *id*. at 3 ("For nearly a century, researchers have recognized that there are fundamental differences between the auditory localization of distant sounds and the localization of sounds near the head. The earliest studies in this area examined the distancedependent changes in the near-field HRTF with a mathematical rigid-sphere model of the head (Hartley & Fry, 1921; Stewart, 1911). Recently there has been renewed interest in near-field localization. The rigid-sphere model has been updated and compared to acoustic measurements on a rigid sphere (Brungart & Rabinowitz, 1996; Duda & Martens, 1998), and an extensive set of nearfield HRTFs have been measured with a Knowles Electronics Manikin for Acoustic Research (KEMAR) (Brungart & Rabinowitz, 1999)."); *id*. ("These studies have shown that, when the source is within 1 m of the listener's head, the HRTF changes substantially with distance.")

- **Gardner 1994** at Abstract ("An extenswive set of head-related transfer function (HRTF) measurements of a KEMAR dummy head microphone has recently been completed. The measurements consist of the left and right ear impulse response from a Realistic Optimus Pro 7 loudspeakermounted 1.4 meters from the KUMAR. Maximum length (ML) pseudo-random binary sequnces were used to obtain the impulse responses at a sampling rate of 44.1 kHz. In total, 710 different positions were sampled at elevations from -40 degrees to +90 degrees. Also measured were the impulse response of the speaker in free field and several headphones placed on the KEMAR. This data is being made availabler to the research community on the Internet via anonymous FTP and the World Wide Web."); *id*. at 2 ("The measurements were made in MIT's anechoic chamber. The KEMAR was mounted upright on a motorized turntable which could be rotated accurately to any azimuth under computer control. The speaker was mounted on a boom stand which enabled accurate positioning of the speaker to any elevation with respect to the KEMAR. Thus, the measurements were made one elevation at a time, by setting the speaker to the proper elevation and then rotating the KEMAR to each azimuth. With the KEMAR facing forward toward the speaker (0 degrees azimuth), the speaker was positioned such that a normal ray projected from the center of the face of the speaker bisected the interaural axis of the KEMAR at a distance of 1.4 meters. This was accomplished using a tape measure, plumb line, calculator, a .4 meter rod, and a fair amount of eyeballing." We believe the speaker was always within 0.5 inch of the desired position, which corresponds to an angular error of +/- 0.5 degrees.")

- **Srinivasan** at 4:35-56 ("The CPU 202 is connected to a network interface 224 such as a modem for communication with the communication network 106. The network interface 224 may be integrated into the user device 102 as shown in FIG. 2. In alternative user devices the network interface 224 is not integrated into the user device 102. The user device 102 also comprises a memory 226 for storing data as is known in



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the art. The memory 226 may be a permanent memory, such as ROM. The memory 226 may alternatively be a temporary memory, such as RAM."), 5:33-67 ("In one embodiment, shown in FIG. 3, the user device 102 is in the form of a headset or head mounted user device. The head mounted user device comprises a frame 302 having a central portion 304 intended to fit over the nose bridge of a wearer, and a left and right supporting extensions 306, 308 which are intended to fit over a user's ears."), 6:20-67 ("These objects or virtual objects can be 'placed' within the image scene and may have a visual representation which can be 'seen' and interacted with by the participants (including the scene owner). Objects may be defined not only by position but comprise other attributes, such as object type and state. The objects, for example, may have associated content such as audio/image/video/text content."), 10:9-34 ("When the object is within the field of view of the user (scene owner) the audio signal can be rendered to the user in any suitable manner for the relative position of the object is visible and therefore easily determined by the user. … The concept as described herein is to enable spatial audio signal processing to be performed on an audio signal associated with the object in such a manner that the audio signal appears to come from the approximate position of the object. This may be implemented for example by applying a suitable head related transfer function (HRTF) to an audio signal in the audio pipeline to produce a spatial output before being passed to the sound card and output."), 10:46-11:17 ("The example as shown in FIG. 5 further may comprise a relative position/orientation determiner 601. The relative position/orientation determiner 601 may be configured to maintain or receive the object position and/or orientation information from the session management entity application 600. The relative position determiner 601 may furthermore be configured to receive user device attributes such as orientation and/or position. The relative position determiner 601 may furthermore be configured to receive other parameters such as the user device's field of view, and the determined or estimated position and/or orientation error or offset information. The relative position determiner 601 may thus in some embodiments be configured to generate a relative listener-source position/orientation defining the spatial relationship between the user device (listener) and the object (source). The spatial relationship in some embodiments may be based on or defined by the relative direction (orientation) from the user device to the object or may be defined by both a relative direction (orientation) and a 'distance' between the user device and the object."), 11:18-12:5 ("In such embodiments the audio position processor 605 may be configured to receive the input audio signal from the audio input buffer 603, the relative position/orientation information from the relative position/orientation determiner 601 and the configuration data from the audio management entity 602. The audio position processor 605 may then generate a suitable processed audio signal output. For example in some embodiments the audio position processor may be configured to apply a head related transfer function (HRTF) using the relative position/orientation information as an input parameter to generate multiple audio output channels from a mono audio input channel."), Figs. 2, 3, 5.

- **Kim 417** at [0043] ("Then, the HMD may be configured to output the filtered virtual audio signal (S250). The HMD may output the filtered virtual audio signal to the audio output unit. According to an exemplary embodiment, the HMD may adjust reproducing characteristics of the filtered virtual audio signal by using the real sound received in



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the step S210. The reproducing characteristics may include at least one of a play pitch and a play tempo. Meanwhile, according to another exemplary embodiment, the HMD may be configured to obtain a position of a virtual sound source of the virtual audio signal. The position of the virtual sound source may be indicated by the user wearing the HMD, or obtained together with additional information when obtaining the virtual audio signal. The HMD may be configured to convert the virtual audio signal into a three dimensional (3D) audio signal based on the obtained position of the virtual sound source, and output the converted 3D audio signal. In this instance, the 3D audio signal may include a binaural audio signal having 3D effects. More specifically, the HMD may be configured to generate head related transfer function (HRTF) information based on the position of the virtual sound source, and convert the virtual audio signal into the 3D audio signal by using the generated HRTF information. The HRTF means a transfer function between a sound wave output from a sound source at arbitrary position and a sound wave arriving at a tympanic membrane of an ear, and its value varies according to the direction and altitude of the sound source. If audio signals without directional nature (i.e. directivity) are filtered using a HRTF of a specific direction, the user wearing the HMD can feel the filtered signal as a sound transferred from the specific direction."); [0050]-[0051] ("T hen, the HMD according to an exemplary embodiment may output the filtered audio content (S350). The HMD may output the filtered audio content to the audio output unit. Meanwhile, according to an exemplary embodiment, the HMD may obtain direction information of a sound source in reference to the HMD. The direction information may include azimuth information of the sound source in reference to the HMD. The HMD may obtain the direction information by using the position information of the sound source and a value of a gyro sensor of the HMD. The HMD may be configured to convert the audio content into a 3D audio signal based on the obtained direction information and information on a distance between the sound source and the HMD, and output the converted 3D audio signal. More specifically, the HMD may generate HRTF information based on the direction information and the distance information, and convert the audio content into the 3D audio signal by using the generated HRTF information. According to an exemplary embodiment, the HMD may be configured to perform the task of converting the audio content into the 3D audio signal prior to or subsequent to the step S340. Also, according to another exemplary embodiment, the HMD may be configured to generate a filter in which the spatial audio parameters extracted in the step S330 and the HRTF are integrated, and filter and output the audio content by using the integrated filter.")

**7. Audio alerts**

Methods for using binaural audio as alerts, including as a response to multiple types of triggers (e.g., boundary, block LOS, object blocks, moving away from an object, voice, audio changes) were well known to a POSA at or before the purported priority dates of the Asserted Claims. Illustrative examples of such methods are disclosed in at least the following:



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- **Sawyer** at [0041]-[0048] (““Without limitation, sensory feedback can be given in the following ways (including combinations), depending on the requirements of each particular implementation:

  a warning sound;

  haptic feedback (rumble or actuators included in the HMD or another wearable device such as a game controller held by the user);

  visual warning signs displayed in the HMD;

  a CG-rendered overlay of the Soft Bounds displayed in the HMD superimposed over the virtual environment;

  a pass-through video signal of one or more cameras mounted on the HMD; and/or a custom application program interface (“API”) trigger sent to the controller of the virtual environment, meaning that the dimensions of the virtual environment are automatically adjusted to the physical environment and/or a custom warning specific to the virtual environment is made (e.g., an in-game character tells the user to stop walking when the user approaches the boundaries of the operating space).

  Any of the above systems and methods may be implemented either as a digital warning signal that is triggered as a user crosses a predefined threshold, or as an analog warning that increases in intensity (e.g., overlay of room bounds fades in in brightness the closer a user gets to an obstacle and gets supported by a rumbling sensation increasing in intensity as user gets even closer).”)
- **Gum** at [0030] (“… When users are playing the virtual reality game, they continue to carry the wireless communications devices 100 that monitor the location of the users, and in the event users exit the playing area boundary 24, one or more types of alerts may be generated by the wireless communications device indicating that the position of the user is outside of the playing area boundary 24. Similarly, if a user comes within a certain proximity of an obstacle 30 within the playing area boundary, the wireless communications device may generate one or more alerts based on the location of the user. As is understood, position determination systems often include an error calculation that may be used to estimate an error in the calculated position of an SPS receiver. In cases where estimated position error is relatively high, this error estimate may be used to determine the probability that any given boundary is exceeded or not, and alerts generated based on such probability. Furthermore, in some embodiments, the location of one or more obstacles 30 may be dynamic, thus moving around within the playing area boundary. For example, the obstacle 30 may be associated with one of the players of the virtual reality game, and in the event that another player of the virtual reality game comes within a predefined proximity of the obstacle, an event may happen to the second player. Similarly, the obstacle 30 may be a static obstacle and represent a hazard within the playing area boundary, such as a hole or a water hazard, and thus players carrying wireless communications devices 100 are alerted in the event that they come within a certain proximity of the obstacle 30, and may thus avoid the obstacle.”)
- **Begault 2000** at 12 (“An example is the problem of simulating the tactile sensation of walking into a virtual wall; hence, some have provided a ‘crashing’ sound through



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headphones when a person walks into a virtual boundary."), 173 ("In virtual reality, one can walk through walls and objects; but by activating auditory information in the form of a bumping or crashing sound, the user receives feedback that a particular physical boundary has been violated.")

- **Clement** at 9:20-31 ("In some embodiments, the transition may include a fade of sound content. For example, when transitioning from the virtual world to the real world, audio content associated with the virtual world may fade out, accompanied by a fade in of ambient sound. In some embodiments, the fade out of virtual audio content and the fade in of ambient sound may accompany the fade out of virtual images and the fade in of real world images. In some embodiments, the fade out of virtual audio content and the fade in of ambient sound may be accomplished serially, so that the ambient sound is not superimposed on, or output at the same time as, the virtual audio content."), *id.* at 12:66-13:10 ("If, at block 1057, it is determined that the transition profile includes audio parameters, then, at block 1058, the virtual audio output associated with the virtual world and output to the user via the audio output device 130 of the HMD 100 may be replaced with transition audio output in accordance with the profile. As discussed above, this replacement of the virtual audio output with transition audio output may include, for example, a serial fade out of the virtual audio followed by a fade in of the transition audio output. The transition audio output may include, for example, the actual sound generated in the real world space 300, a preset tone, no sound, and the like."), Abstract ("A system and method of operating an audio visual system generating a virtual immersive experience may include an electronic user device in communication with a tracking device that may track a user's physical movement in a real world space and translate the tracked physical movement into corresponding movement in the virtual world generated by the user device. The system may detect when a user and the user device are approaching a boundary of a tracking area and automatically initiate a transition out of the virtual world and into the real world. A smooth, or graceful, transition between the virtual world and the real world as the user encounters this boundary may avoid disorientation which may occur as a user continues to move in the real world, while motion appears to have stopped upon reaching the tracking boundary."), 1:24-30 ("In one aspect, a method of operating an audio visual system configured to generate a virtual immersive experience may include activating a tracking device and tracking a position of a user electronic device in a real world space, detecting a transition condition, and performing a transition process to transition out of the virtual world generated by the user electronic device in response to the transition condition."), 1:31-42 ("In another aspect, a method of operating an audio visual system configured to generate a virtual immersive experience may include activating a tracking device having a defined tracking area and tracking movement of a user electronic device the real world space, translating the real world movement of the user electronic device in the real world space into virtual movement in a virtual world generated by the user electronic device, determining when a current position of the user electronic device is within a threshold of a system boundary, and performing a transition process when the current position of the user electronic device is within the threshold of the system boundary."), 1:43-63 ("In another aspect, an audio visual system may include a user electronic device generating a virtual world experience, the user electronic device being movable within the real world space, a tracking device in communication with



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the user electronic device, the tracking device tracking a position of the user electronic device in the real world space and real world movement of the user electronic device in the real world space, and a processor. The processor may translate the detected real world movement of the user electronic device into virtual movement in the virtual world generated by the user electronic device, may automatically perform a transition out of the virtual world generated by the user electronic device when a distance between the tracking device in the tracking area and a boundary of the tracking area is less than or equal to a preset threshold distance such that the transition out of the virtual world is complete at or before the user electronic device reaches the boundary, and may perform a transition back into the virtual world by the user electronic device when the tracking device detects that the user electronic device has crossed the boundary and re-entered the tracking area."), 2:43-62 ("A Virtual Reality (VR) system and/or an Augmented Reality (AR) system may include, for example, a head mounted display device (HMD) or similar device worn by a user, for example, on a head of the user, to generate an immersive VR environment to be experienced by the user. Movement of the user in the real world may be translated into corresponding movement in the environment generated in the virtual world. Differences in the physical boundaries of the real world, such as, for example, the confines of a room and/or objects in the room, and boundaries of the virtual world may cause discrepancies or disruptions in the immersive experience and disorientation as the user approaches and/or encounters one of these virtual boundaries and/or one of these physical boundaries. A smooth, or graceful, transition, for example, from the virtual world to the real world as the user encounters a boundary of the virtual world, may avoid the disorientation and motion sickness which may occur as a user continues to move in the real world, while motion appears to have stopped upon reaching the boundary of the virtual world."), 3:20-4:5 ("A block diagram of a system 200 for transitioning from a virtual/augmented reality environment to an ambient environment in shown in FIG. 2. The system 200 may include a user electronic device 250, such as, for example an HMD as described above with respect to FIGS. 1A-1C, to generate the virtual reality environment, in communication with a tracking system 240 that tracks a user position in a real world, physical space, so that the user's physical movement in the real world space may be translated into movement in the virtual reality world by the system 200. The device 250 may include a sensing system 260 and a control system 270, which may be similar to the sensing system 160 and the control system 170, respectively, shown in FIGS. 1A-1C. In the example embodiment shown in FIG. 2, the sensing system 260 includes a light sensor 262, a distance/proximity sensor 263 and an audio sensor 264, and the control system 270 includes a power control device 271, a pause control device 272, a manual audio control device 273, a manual video control device 274, a rotation control device 275 to control rotation of the housing relative to the frame, an optical adjustment control device 258 to adjust optical components of the device 250, and a transition control device 276 to control transitions between the virtual environment and the ambient environment."), 4:61-5:16 ("At positions 1, 2 and 3 shown in FIG. 3A, because the user A is within the tracking area 320, movement of the user A in the real world space 300 tracked by the tracking device 310 may be translated into corresponding movement in the virtual world. At position 4, the tracking device 310 may still track movement of the user A in the real world space 300 and translate that tracked real world



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movement into movement in the virtual world. However, due to the user's proximity to the edge of the tracking area 320, or the point at which the tracking device 310 can no longer track the movement of the user A, it may be considered that, at position 4 the user A is about to exceed a predetermined threshold at which loss of tracking may be near, or imminent, as at position 5. That is, as discussed above, if the user A continues to move in the room 300 after tracking of the user A by the tracking device 310 is lost, the virtual world may remain still, or appear stuck, while the user A continues to move, which may cause disorientation, motion sickness, dissatisfaction with the virtual immersive experience and the like. A fluid, or graceful, transition from the virtual world to the real world, before actually reaching this still or stuck point in the virtual world, may alleviate the negative effects of disorientation, motion sickness and the like."), 5:55-6:6 ("In some embodiments, the tracking device 310 may not just track the physical position and movement of the user A in the space 300, but may also detect when the user A is within a predetermined distance, or threshold, of a boundary or edge of the tracking area 320, at which loss of tracking may be imminent. As shown in the example illustrated in FIG. 3B, this loss of tracking by the tracking device 310 may be considered imminent when, for example, the zone Z approaches the boundary of the tracking area 320, in advance of when the user actually moves into an area of the space 300 which cannot be tracked by the tracking device 310. For example, the system may issue a warning or indicator, and/or may automatically initiate a fluid or graceful transition out of the virtual world when the user is at position 4, even though the user is still in the tracking area 320 at position 4, so that by the time the user reaches position 5, the transition out of the virtual world will be complete, and the user may avoid disorientation and/or discomfort due to the loss of tracking."), 6:7-56 ("As shown in FIG. 3C, the user is completely within the tracking area 320 at position 3A. As the user moves from position 3A to position 3B, the user approaches the point at position 3B at which the edge of the established 3 foot radial zone meets the boundary of the tracking area 320. As the HMD 100 and/or the tracking device 310, or other component of the system, determines that the user is positioned within the preset threshold (in this particular example, 3 feet of the boundary of the tracking area 320, as at position 3B), the system 100 may initiate a gradual transition out of the virtual world. At position 4, the user has moved closer to the boundary of the tracking area 320 (for example, within 1 foot of the boundary as shown in the example illustrated in FIG. 3C). At position 4, the transition out of the virtual world may be at least partially complete, with the transition process fully complete by the time the user reaches position 5 and is fully outside of the tracking area 320."), 6:58-7:3 ("This example of a linear progression of the transition from the virtual world to the real world is just one example of how the transition between the virtual world and the real world may be accomplished. In some embodiments, the transition between the virtual world and the real world may follow, for example, a non-linear profile, a stepped profile, or other profile based on various different factors as noted above. In some embodiments, the system may automatically adjust the transition profile, such as, for example, selecting a different transition profile and/or adjusting an acceleration rate of the profile, based on, for example, changes in speed at which the user is approaching the boundary, changes in direction of the user, and other such factors."), 8:10-35 ("As noted above, in some embodiments the system may generate a warning indicator and/or initiate the transition process upon detection



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of obstacles, i.e., stationary obstacles, already present in the room, such as, for example, furniture and the like. The warning indicator may include, for example, a visual indicator and/or an audible indicator and/or a physical indicator such as, for example a buzz or vibration of the HMD 100. The system may also generate a warning indicator and/or initiate the transition process upon detection of new obstacles detected as the tracking device 310 scans and updates the configuration of the space 300, such as, for example the opening of the door 315 shown in FIG. 5B. In some embodiments, the system may also generate a warning indicator and/or initiate the transition process in a situation in which, for example, another person approaches the user. This may be implemented to avoid collision between multiple players in a scenario in which multiple players or users are in the same space 300, engaged in a virtual reality immersive experience, in a situation in which another person requires the attention of the user, and other such circumstances. As noted above, the rate at which the warning indicator and/or the transition process is initiated and carried out, may be based on numerous different factors, including, for example, the nature of the virtual reality immersive experience, the speed and/or direction of the user(s) in the space 300, and the like."), 8:36-59 ("In some embodiments, the transition between the virtual world and the real world may be initiated, for example, as the user approaches the boundary of the tracking zone 320, or when an obstacle is detected in the path of the user, when another user engaged in the VR experience is in the path of the user, when another person requires the attention of the user, and other such situations as discussed above in more detail. In some embodiments, when transitioning from the virtual world to the real world, the transition may include a gradual fade of the image displayed on the display 140 of the HMD 100. The gradual fade may include a gradual fade from the image associated with the virtual world to, for example, a monochromatic display, such as, for example, an all white screen, or an all black screen and the like. In some embodiments, the transition may include the display of pass through images of the real world environment on the display 140, captured by, for example, the camera 180 on the HMD 100. In some embodiments, these pass through images may be, for example, superimposed on, or ghosted on, the virtual reality images displayed on the display 140. In some embodiments, the display 140 of the HMD 100 may be a transparent display, allowing the real world environment to be viewed through the display 140 after the virtual images are no longer displayed."), 11:66-12:19 ("FIG. 10 is a flowchart of a process for initiating a transition between a virtual environment and an ambient environment, in accordance with embodiments as broadly described herein. As shown in FIG. 10, at block 1010 the user may activate the system, including the HMD 100, to allow the HMD 100 to generate the virtual immersive experience and the tracking device 310 to track the user in the space 300 as described in detail above. If, at some point during operation of the system, a transition command is received, as at block 1020, the transition process may be initiated at block 1050. As described in detail above, the transition command may be, for example, a direct request input by the user, for example via the control system 170 of the HMD 100 or other user gesture or keyword recognized by the HMD 100. In some embodiments, the transition command may be a gesture, or keyword, or other such input from an external party that is recognized by the HMD 100. In some embodiments, the transition command may be, for example, detection of an obstacle in the path of the user that triggers transition out



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of the virtual world, as described in detail above."), 12:20-29 ("In the absence of a specific command to transition from the virtual world, the HMD 100 and/or the tracking device 310 may determine a current position of the user in the tracking area 320 at block 1030, as described above. If it is determined, at block 1040, that the user is within a set threshold or range of the boundary of the tracking area 320, at which loss of tracking by the tracking device 310 may be imminent, the transition process may be initiated at block 1050. The transition process is shown in more detail in FIG. 11."), Figs. 1A-1C, 2, 11.

- **Jang** at 7:64-8:3 ("The control unit 114 may further detect virtual space shift of the character and control the operation of the sound processing unit 116 so as to cause the sound processing unit 116 to, for example, gradually decrease the volume of the sound of a first space while gradually increasing the volume of the sound of a second space when the character shifts from the first space to the second space.")
- **Jerald** at 149 ("Auditory cues are especially good for grabbing the attention of a user to prepare for some important event."), *id.* at 305 ("Audio cues are very effective in conveying to a user that one of his hands has collided with some geometry. Audio might be as simple as a tone sound or real-world recorded audio track. In some cases, providing multiple audio files with variations (e.g., random grunt sounds when colliding with a virtual wall or when shot by an enemy) can help with a sense of realism and reduce annoyance. Continuous contact sounds can also be used to convey sliding along surfaces. Sound properties such as pitch or amplitude might also change depending on penetration depth.")
- **Pedrotti** at 15:53-58 ("Also as above, in various embodiments, the processor can generate the visual warning in the form of grid lines or a virtual fence, or in any other desired shape or configuration. In some embodiments, it may again be appropriate to generate an audio warning as well, or instead of, the visual warning.")
- **Zhou** at 1060 ("To examine the impact of 3D sound on task completion time and subjective feelings in this AR environment, 3D sounds were applied in this experimental game. Their functions are summarized as follows:

  1. Players' sounds. A constant buzz sound is applied to the co-player's airplane when the users are exploring the augmented land. Since the plane is attached to the wand, the 3D positions can be easily obtained from the tracker in the wand. By applying this sound, the user can always hear where is the location of the co-player, even when the co-player is not visually in the scene. She can still roughly tell to what direction is her co-player located and whether the co-player is getting closer or further to her. This buzzing sound is changed into a footstep sound when the co-player enters the VR environment. The different sound gives the hint of whether the co-player is in the AR or VR environment as well.

  2. Human voice. A constant human voice 'Help! Help!' is applied to the princess which is the target of the searching task. This sound helps the player to turn and face to the correct direction and walk to the correct location where she can see the princess through the small window."), 1066 ("The 3D sound generated by OpenAL (Loki Entertainment Software) applying HRTFs and simple modeling of environment is used in our experiments. Apart from its effects for the user on sound



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source localization, we tried to emphasize its effect on telling the depth (distance). Since intensity has been reported to be a key cue for distance perception, we exaggerated the intensity difference of sound sources in different depth by applying an additional scalar factor to the intensity of generated 3D sound. The user study result shows that it is still intuitive. These methods to implement 3D sound in relative small AR environments provide a necessary foundation for the incorporation of 3D sound with visual AR environments.")

**8. Filtering or processing of binaural audio**

Methods for filtering or processing of binaural audio were well known to a POSA at or before the purported priority dates of the Asserted Claims. Illustrative examples of such methods are disclosed in at least the following:

- **Andrea** at 15:47-57 ("A sound is picked up by the audio receiving means on each earbud, converted into audio signals, and transmitted to an external device, such as a computing device, for processing. The processor of the computing device may then execute executable instructions causing the processor to generate an audio signal corresponding to a sound wave having an inverted phase with respect to the original sound, using ANR processing techniques known to one of ordinary skill in the art."), 16:21-27 ("That is, the sound picked up by the audio receiving means on the earbuds may be converted to audio signals that are transmitted to an external device comprising a processor for processing. The processor may execute executable instructions causing it to generate an audio signal that substantially fails to reflect noise generated from an area outside of the beam width.")
- **Ballas 439** at 2:25-2:53 ("Another method, often used with headphones, requires complex individual filters or synthesized sound reflections. This method performs filtering of a monaural source with a pair of filters defined by a pair of head related transfer functions (HRTFs) for a particular location. Each of these methods have limitations and disadvantages. The latter method works best if individual filters are used, but the procedure to produce individual filters is complex. Further, if individual filters or synthesized sound reflections are not used, then front-back confusions and poor externalization of the sound source would result. Thus, there is a need to overcome the above-identified problems."), 4:21-26 ("FIG. 2 shows another embodiment of the present invention as in FIG. 1. Here, the processor 102 also performs the HRTF filtering functions. The audio source is generated and operates under the control of the computer system. The rest of the operation of FIG. 2 is similar to the operation as explained with respect to FIG. 1."), Figs. 1 and 2.
- **Etter 419** at [0063] ("Binaural mixer 1005 then generates a pair of stereo binaural audio signals, in accordance with the principles of the present invention and in accordance with an illustrative embodiment thereof, which will advantageously provide improved matching of auditory space to visual space. In accordance with one illustrative embodiment of the present invention, viewer 1012 uses headphones (not shown in the figure as representing a different illustrative embodiment of the present



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invention) which comprises a pair of speakers (a left ear speaker and a right ear speaker) to which these two stereo binaural audio signals are respectively and directly provided.")

- **Bedingfield** at 2:4-16 ("Additional methods and systems for providing synthetic audio placement are described herein. In different aspects, the methods and systems may include a connection port to receive a plurality of remote audio signals included in a conference call, at least one of the plurality of remote audio connections being a single channel audio signal, a processor configured with the connection port to provide a sound field for placing the plurality of audio signals, the sound field providing synthetic audio placement of each of the plurality of remote audio signals, and a rendering output configured with the processor to project the plurality of remote audio within the sound field to a listener."), 8:4-22 ("The processing device 402 may be used in other embodiments. The processing device 402 may actually provide the synthetic audio placement processing by receiving all signals from all participants, either separately or in multiplexed, multi-channel, or specially encoded format. In this embodiment, both the control and the signal processing may take place in the processing device 402. Alternatively, the processing device 402 may serve as a remote control for a separately-located synthetic audio placement bridge circuit, as indicated by the communications bridge 422. In this embodiment, the connectivity to the processing device 402 includes a control channel, over which the processing device 402 and the communications bridge 422 may exchange control signals, and a signal channel, over which the listener may receive the two or more audio channels containing all of the participant audio, arranged in synthetic audio placement format as determined by the system 400. Further embodiments of the conference bridge are discussed in greater detail below.")

- **Clement** at 9:20-31 ("In some embodiments, the transition may include a fade of sound content. For example, when transitioning from the virtual world to the real world, audio content associated with the virtual world may fade out, accompanied by a fade in of ambient sound. In some embodiments, the fade out of virtual audio content and the fade in of ambient sound may accompany the fade out of virtual images and the fade in of real world images. In some embodiments, the fade out of virtual audio content and the fade in of ambient sound may be accomplished serially, so that the ambient sound is not superimposed on, or output at the same time as, the virtual audio content."), *id.* at 12:66-13:10 ("If, at block 1057, it is determined that the transition profile includes audio parameters, then, at block 1058, the virtual audio output associated with the virtual world and output to the user via the audio output device 130 of the HMD 100 may be replaced with transition audio output in accordance with the profile. As discussed above, this replacement of the virtual audio output with transition audio output may include, for example, a serial fade out of the virtual audio followed by a fade in of the transition audio output. The transition audio output may include, for example, the actual sound generated in the real world space 300, a preset tone, no sound, and the like.")

- **Jang** at 7:64-8:3 ("The control unit 114 may further detect virtual space shift of the character and control the operation of the sound processing unit 116 so as to cause the sound processing unit 116 to, for example, gradually decrease the volume of the sound of a first space while gradually increasing the volume of the sound of a second space



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when the character shifts from the first space to the second space."), 1:57-2:11 ("When a user moves in a virtual environment, the real world is imitated as much as possible. However, in some situations it may be more convenient for a user if movement in the virtual environment does not precisely mimic the real world. For example, unlike the real world in which a user cannot avoid making a continuous movement according to the passage of time, in a virtual environment, a user can shift between virtual spaces without having to portray the passage of distance or time to travel from one space to another. An example of such a virtual reality system includes a virtual reality game, "Second Life," developed by Linden Lab of the United States. In such a virtual reality system, when a character of a user shifts between virtual spaces, the image viewed by the user and the sound heard by the user should change according to the shift between spaces or the change of the spaces. Since the spaces between which the character shifts are different from each other, the two sounds heard in the spaces are output from different sound sources. Therefore, there may be a time delay between the sound outputs during the space shift, which may degrade the sense of reality in the sound. Therefore, a sound processing technique is needed to provide a virtual reality that can give a higher sense of realism."), 11:1-16 ("However, as discussed above, a delay may occur between when a space shift is detected and when the sound of the second space is received. According to an embodiment of the present general inventive concept, to minimize the time delay occurring during the space shift from the basket ball court 600 to the conference room 610, priorities of the sound sources of a focus area and non-focus areas of the conference room 610 are first determined. Then, as shown in (b) of FIG. 6, the volume of the basket ball court sound 607 is decreased or faded while the volume of the conference room sound 617 generated according to the priorities of the focus area or non-focus areas of the conference room 610 is increased. This sound volume control method can be expressed by the portion designated by reference numeral 620 of FIG. 6. The sound conversion process during the virtual space shift will be described with reference to FIG. 7.")

- **Zhou** at 1044-1045 ("A few applications have applied 3D sounds in AR to enhance user experiences. Billinghurst et al. (1998) presented a prototype wearable communication space that uses spatial visual and audio cues to enhance communication between remote groups of people. The 'Listen Project' (Eckel et al., 2001) provides users with intuitive access to personalize and situated audio information spaces while they naturally explore everyday environments. It augments the physical environment through a dynamic soundscape, which are presented to the user over motion-tracked wireless headphones. The 'Magic Music Desk' (Zhou et al., 2002) synthesize virtual sound sources on fiducial markers from which 3D position information was retrieved by vision-based tracking method (Kato and Billinghurst, 1999). 'Touch space' (Cheok et al., 2002) applied different 3D sounds to represent different moving avatars in AR environment. Although there are quite a few AAR applications, the effectiveness of 3D sound in AAR has been rarely investigated. The particular research problems and questions that arise are: . . . 4. Normally the space of AR environments is relatively small, and the attenuation of sound with distance in this small area can be too vague to be perceived. This is because in most 3D sound systems, the intensity of sound (a very strong distance cue) would follow incremental reductions of 6 DB for each successive position of doubled distance (Begault, 1994). This means that for small areas, the 3D



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sound hardly plays a role to provide a cue to the depth (or the distance of the frontal sound sources). In order to make 3D sound give a cue to depth in a small space, we need to exaggerate the intensity difference of 3D sound according to distance (depth) changes of the virtual sound sources. However, this leads to a new issue, which is to research if this exaggeration will ruin the realistic and immersive feeling, which we have been focused on. It needs to be investigated what are the subjective feelings on this exaggeration to the human."), 1044-1045 (""Sound intensity has been shown to be a key cue in distance perception in humans. However, in the small physical spaces used in AR systems, the human is only effectively provided with binaural cues from the synthesizer. Thus, we try to also add the effect of intensity for the depth cue. Our approach is to exaggerate the intensity difference of sound sources in different depths by applying an additional scaling factor to the intensity of 3D sound generated by synthesizer. The intensity of the *i*th 3D sound Vi is given by Eq (1):

$$Vi = (Dmax - Di) \times Vi/Dmax \quad (1)$$

where Di is the depth of the ith 3D sound source; Vi is the intensity of the ith 3D sound generated by synthesizer given the position of the ith sound source. Dmax is the possible maximum distance of the sound sources which is subject to the space of different AR environments. We measured the space in our first and second experiments and the maximum distance was 1.5 and 5.5 m, respectively.")

- **Begault 2000** at 16-17 ("Figure 12 shows a possible audiospatial map for establishing a simple spatial grammar that indicates whether a command is urgent or not. The spatial positions shown could be applied for indicating the relative urgency of a command. The numbered dots represent perceived positions: Position 1 was synthesized with a diotic signal (the same signal to both ears), Position 2 was synthesized with a dichotic time-delay difference, and Position 3 was synthesized with a relatively larger dichotic time delay and amplitude differences. One possible semantic organization for this set of positions is for the most urgent warning to be processed to appear at Position 1. Less urgent commands are assigned to Position 3 or 5. If a sound is transformed from the perceived side positions to one directly inside the head, there is a sort of infringement of the listener's personal space. It is suggested that, with minimal training, a pilot could easily associate a sound inside the head as occupying an urgency space-relative to sounds that are perceived to the sides."), 132 ("The panpot (panoramic potentiometer) has already been discussed as a means of moving virtual sound sources in space with a traditional mixing console. The amplitude is smoothly weighted from one channel to another, or special functions can be used to create a moving virtual source on the basis of ILD cues. But because a 3-D sound system uses HRTFs, a frequency-dependent change in level must occur when a sound source (or the receiver) moves. Furthermore, changes in the ITD cues contained within the binaural HRTF are necessary."), 3 (describing environmental context and reverberation), 20 ("The technological context for implementing 3-D sound is directly tied to both the evolution of digital signal processing (DSP) chips for the defense industry, and the commercial introduction of digital audio in the music industry. It was not so long ago that digital representation and manipulation of sound was confined to specialized laboratories. Since their introduction in the United States in 1983, it took only eight years for digital audio technology in the form of the compact disc (CD) to penetrate 28 percent of households



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(Pohimann, 1992). Simultaneously, the development of DSP chips, which are capable of millions of computational instructions per second, have over time been increasingly used in everyday audio and graphics applications, and not merely for missile guidance or radar systems."), 40-41 (describing spectral cues), 49-50 (describing localization with HRTF cues), 69 (The inclusion of distance and environmental context effects within a 3-D audio system is almost imperative for maintaining a sense of realism among virtual acoustic objects. In fact, the same physical cue—reverberation is key for the effective simulation of distance and the perception of an environmental context"), 100 ("Within a virtual reality or multimedia application, 3-D sound processing is almost always best accomplished digitally, using audio DSP chips to manipulate signal sources. A DSP can be used to process any type of digitally stored information: visual, audio, subsonic vibration, or magnetic fields. … Audio DSP chips typically are designed to perform a limited set of digital DSP instructions *very quickly*—i.e., in real time."), 165-170 (DSP for HRTF processing), 185-187 (same).

- **Sauk 2007** at 2 ("Another configuration is combining any number of dimensions such as 3-D (binaural), 2-D (stereophonic), 1- D (monophonic). This capability provides the listener with the desired audible information to help improve his understanding of the environment. In certain cases, the listener may not want to eliminate all the unwanted audio information. Rather than keep the less relevant audio in the same audio dimension with their desired binaural sound sources, the listener could change the less relevant audio to a monophonic (1-D) or stereophonic (2-D) dimension. The effect of changing sounds from binaural to monophonic/stereophonic audio places the sound in the listener's head and signifies a different level of relevancy or importance. This removes any localization cues for that audio. Begault calls this effect the Inside Head Localization (IHL) [12]. Additionally, the listener would be able to adjust the decibel level of the 1-D or 2-D audio to the level of importance the listener desires for that dimension.")
- **Sandgren** at [0009]-[0010] ("In simulating an audio scene or creating a virtual audio scene, the sound sources' direct sounds are usually generated by filtering a monophonic sound source with two head-related transfer functions (HRTFs), one for each of left and right channels. These HRTFs, or filters, are usually determined from measurements made in an anechoic chamber, in which a loudspeaker is placed at different angles with respect to an artificial head, or a real person, having microphones in the ears. By measuring the transfer functions from the loudspeaker to the microphones, two filters are obtained that are unique for each particular angle of incidence. The HRTFs incorporate 3D audio cues that a listener would use to determine the position of the sound source. Interaural time difference (ITD) and interaural intensity difference (IID) are two such cues. An ITD is the difference of the arrival times of a sound at a listener's ears, and an IID is the difference of the intensities of a sound arriving at the ears. Besides ITD and IID, frequency-dependent effects caused primarily by the shapes of the head and ears are also important for perceiving the position(s) of sound source(s). Due to the absence of such frequency-dependent effects, a well known problem when listening to virtual audio scenes with headphones is that the sound sources appear to be internalized, i.e., located very close to a listener's head or even inside the head."), [0021] ("Simulating the early reflections properly is important for achieving good


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externalization of virtual sound sources when listening through earphones."), [0023] ("In accordance with aspects of this invention, there is provided a method of generating signals that simulate early reflections of sound from at least one simulated sound-reflecting object."), [0024] ("In accordance with further aspects of this invention, there is provided a generator configured to produce, from at least first- and second-channel signals, simulated early-reflection signals from a plurality of simulated sound-reflecting objects."), [0025] ("In accordance with further aspects of the invention, there is provided computer-readable medium having stored instructions that, when executed by a computer, cause the computer to generate signals that simulate early reflections of sound from at least one simulated sound-reflecting object."), [0046] ("As noted above, properly generating simulated early reflections is important for externalization of virtual sound sources that are rendered for listening via headphones . . . Simplifications can be made to reduce the computational complexity of the simulation method in such processors, but the simplifications must not reduce the quality of the simulation results.", [0048] ("In accordance with this invention, an HRTF-processed direct-sound signal is used for generating simulated early-reflection signals but is modified in order to approximate the spectral content of the early reflections. This results in enhanced externalization of virtual sound sources. Furthermore, by using cross-coupling in the early-reflection generator, a good approximation of reflections coming from the other side of the listener compared to the direct sound path can be achieved . . . Thus, the modification parameters of the early-reflection generator can be held constant and one early-reflection generator can be used for multiple virtual sound sources."), [0049] ("FIG. 5A is a block diagram of a sound-scene simulator 500 that includes HRTF filters $H_{l,0}(z)$, $H_{r,0}(z)$, an early-reflection generator 502, and two attenuation filters $A_0(z)$ 504, 506, one for each of left and right channels . . . The outputs of the attenuation filters 504, 506 and the early-reflection generator 502 are combined by respective summers 508, 510 that produce left-channel and right-channel (stereophonic) output signals."), [0061] ("If the distance attenuation is implemented as a gain, the compensation is easily implemented through suitable gain adjustments."), [0076] ("The attenuation filter for the direct sound, $a_0(n)$, simulates the distance attenuation and can be implemented as a low-pass filter or more commonly as a frequency-independent gain. It is also possible to include the effects of obstruction and occlusion in the attenuation filter, and both effects usually cause the sound to be low-pass filtered. The attenuation filters for the reflections, $a_k(n)$, simulate the same effects as the attenuation filter for the direct sound, but here also the attenuation of the sound that occurs during reflection may be considered. Most materials absorb high-frequency energy more than low-frequency energy, which results in an effective low-pass filtering of the reflected sound."), [0100] ("The above-described systems and methods for simulating 3D sound scenes and early reverberations provide early reverberation that sounds good with good externalization at low computational cost. In comparison to prior efforts, the above-described systems and methods enjoy the benefits of reusing the spectral content of the simulated direct sound, which removes the computationally costly HRTF filtering needed for each early reflection. In addition, cross-coupling in the early-reflection generator provides good approximations of reflections coming from a side of a listener opposite to that of the direct sound, and also results in a balanced intensity difference between left and right channels of the early reverberation. The modification parameters



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of the early reflection generator can be kept constant, which means that no update is needed when the sound source(s) and/or the listener move and that the same generator can be used for an arbitrary number of sound sources without increasing the computational cost. The early-reflection generator is scalable in the sense that the computations and memory required can be adjusted by changing the number of reflections that are simulated, and the early-reflection generator can be applied to audio data that already has been 3D audio rendered in order to enhance the externalization of such data."), [0101] ("It will be recognized that various actions could be performed by specialized circuits (e.g., discrete logic gates interconnected to perform a specialized function or application-specific integrated circuits), by program instructions executed by one or more processors, or by a combination of both. Many communication devices can easily carry out the computations and determinations described here with their programmable processors and associated memories and application-specific integrated circuits."), Figs. 5A, 5B, 6B, 7A, 8

- **Schroder** at 5:21-6:3 ("In the inventive method according to Claim 1, changes in the position of the listener or of his head which are for a limited time or are relatively frequent are detected and a control variable is derived therefrom. Normally, the head points in one preferred direction when listening to aural events, normally forwards in the direction of the front of the trunk. A change in the position of the listener which is for a limited time or is relatively frequent is when the listener turns his head, for example. The signals for the left and right ears are adjusted, on the basis of the position of the listener or of his head, using variable filters for the HRT function such that the direction from which the aural event appears to come remains stable in space, that is to say has a constant spatial direction. A change in the position of the listener which is for a longer time or is relatively infrequent results in the direction from which the aural event appears to come being matched to the new preferred direction.")

- **Jarvinen** at 8:1-34 ("The processor 70 may be embodied in a number of different ways. For example, the processor 70 may be embodied as one or more of various processing means such as a coprocessor, microprocessor, a controller, a digital signal processor (DSP), processing circuitry with or without an accompanying DSP, or various other processing devices including integrated circuits such as, for example, an ASIC (application specific integrated circuit), an FPGA (field programmable gate array), a microcontroller unit (MCU), a hardware accelerator, a special-purpose computer chip, or the like. In an example embodiment, the processor 70 may be configured to execute instructions stored in the memory device 76 or otherwise accessible to the processor 70. As such, whether configured by hardware or software methods, or by a combination thereof, the processor 70 may represent an entity (e.g., physically embodied in circuitry) capable of performing operations according to an embodiment of the invention while configured accordingly. Thus, for example, when the processor 70 is embodied as an ASIC, FPGA or the like, the processor 70 may be specifically configured hardware for conducting the operations described herein. Alternatively, as another example, when the processor 70 is embodied as an executor of software instructions, the instructions may specifically configure the processor 70 to perform the algorithms and operations described herein when the instructions are executed. However, in some cases, the processor 70 may be a processor of a specific device (e.g.,



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a mobile terminal or network device) adapted for employing an embodiment of the invention by further configuration of the processor 70 by instructions for performing the algorithms and operations described herein. The processor 70 may include, among other things, a clock, an arithmetic logic unit (ALU) and logic gates configured to support operation of the processor 70.")

- **Flaks 968** at 5:67-6:3 ("The processor 32 may include a standardized processor, a specialized processor, a microprocessor, or the like that may execute instructions including, for example, instructions for generating a 3D audio signal."), 7:14-16 ("In some embodiments, an HRTF for the listener is applied to form the 3D audio signal."), 14:27-39 ("In order to calculate the azimuth and elevation of the reflections, data from box 1020 and 1030 may be used. Similarity, the gain and filters may use the data from box 1020 and 1030. Note that the sensor data may be updated at any time. For example, the user might be moving such that the sensor data that captures user location changes quite frequently. These changes may be fed into, for example, the azimuth and elevation calculations 1004 such that the 3D audio signal is constantly being updated for the changing user position. Similarly, the change in user position may be fed, in real time, to the gain and filters 1006. In some embodiments, the HRTF for the user is not updated in real time. However, updating the HRTF for the user in real time is one option."), Figs. 10-12
- **Pedersen** at 6:8-14 (""For example, a first binaural filter may be configured to output signals intended for the right ear and left ear of the user of the hearing device system that are phase shifted with relation to each other in order to introduce a first interaural time difference whereby the perceived position of the corresponding first sound source is shifted outside the head and laterally with relation to the user of the hearing device system. In the event that the output signals intended for the right ear and left ear are phase shifted 180° with relation to each other, sense of direction is lost; however, many humans find speech signals phase shifted 180° with relation to each other easy to separate from other signal sources and easy to understand."), 16:7-16 ("The directional transfer functions of the binaural filters may be individually determined for the user of the hearing device system 10, whereby the user's perceived externalization of and sense of direction towards the various sound sources 102, 104, 106, 108, 110 will be distinct since the HRTFs will contain all information relating to the sound transmission to the ears of the user, including diffraction around the head, reflections from shoulders, reflections in the ear canal, etc., which cause variations of HRTFs of different users.")
- **Hammershoi** at [0019] ("Preferably, the method includes deriving a measure of interaural time delay (ITD) based on the first and second positions. Since the two ear positions are determined, it is possible from a known simple relation to determine a measure of ITD for the listener, i.e. also a measure of a size of the head of the listener."), *id.* at [0061]-[0062] ("Applications such as decomposition of an auditory scenario is advantageous with the position tracking according to the invention, since an actual ITD of the listener can estimated based on the 3D positions PL(X,Y,Z), PR(X,Y,Z), whereas in prior art head tracking systems only a mid-point of the listener's head and its orientation is known, i.e. no ITD can be derived. The mentioned further signal processing may include mixing virtual sound sources with the real auditory event picked up by the microphones in the audio inserts E2. E.g. when the listener walks



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around in a real life environment, it is possible to have a transparent auditory impression of the environment using the microphones that bypasses sound to the loudspeakers. Since the position of the listener's ears is known, it is possible to synthesize a virtual sound at a desired location relative to the listener. Such virtual sound may be used to make the listener part of a teleconference still walking around in a workplace. One distinct location in space relative to the listener can be used for each person participating in the teleconference, thus improving speech intelligibility even if the listener is still capable of noticing calls or warning signal in the workplace environment.")

- **Knappe** at 8:1-15 ("Channel mappers 96 and 98 can position the apparent location of their assigned conferencing endpoints within the presentation sound field by manipulating ITD and/or ILD for their assigned voice data channels. If a conferencing endpoint is broadcasting monaurally and the presentation system uses stereo, a preliminary step can be to split the single channel by forming identical left and right channels. Or, the single channel can be directly mapped to two channels with appropriate ITD/ILD effects introduced in each channel. Likewise, an ITD/ILD mapping matrix can be used to translate a monophonic or stereophonic voice data channel to, e.g., a traditional two-speaker, 3-speaker (left, right, center) or 5.1 (left-rear, left, center, right, right-rear, subwoofer) format.")
- **Boustead** at 25:56-26:5 ("Alternatively or in addition to determining a particular talker as being dominant, a talker may be tagged (by default) as being dominant. For example, if a participant in a call is the chairperson or the main presenter, this person may be tagged as being dominant. The conference controller 111 may be configured to place the default dominant talker into a centermost location, as long as no other dominant talker has been determined. If the actual dominant talker is not the chairperson, the actual dominant talker may be moved to the next most central location instead of replacing the chairperson in the most central location.")
- **Gardner** at 13:6-14 ("Reverberation is particularly important. Spatialized audio that lacks reverberation is often perceived as being inside or near to the head of the listener; adding reverberation enables externalized perception. Spatial teleconferences that include reverberation sound like the users are sharing an acoustical space, rather than simply sharing a headset transducer. Reverberation imparts useful cues as to the surrounding space, so it is an important audio effect to faithfully recreate a believable virtual world.")
- **Algazi 2011** at 34 ("One approach uses so-called head-related transfer functions (HRTFs) to filter the signals from the source in a way that accounts for the propagation of sound from the source to the listener's two ears. This approach requires having HRTFs and isolated signals for every source and uses HRTF interpolation to account for head motion. The other approach, motion-tracked binaural (MTB), is based on sampling the sound field sparsely in the space around a real or virtual dummy head. MTB requires knowing the signals at multiple points around the head and uses interpolation of the signals from these microphones to account for head motion. For both methods, the essential dynamic cues that are generated by head motion can now be achieved by low cost, low-power, small-size head trackers based on



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microelectromechanical systems (MEMS) technology. Thus, the development of new signal processing methods that respond to the dynamics of human motion promises a new era in immersive binaural audio applications for mobile communications.")

- **Osman** at 4:48-67 ("One example of a sound localization function is a Head-Related Transfer Function (HRTF), which is a response that characterizes how an ear receives a sound from a point in space. A pair of HRTFs for the ears may be utilized to synthesize a binaural sound that seems to come from a particular point in space."), 9:49-65 ("In FIG. 4, virtual objects include helicopters 414 a-414 c, clouds, birds, sun 416, etc. … As seen in FIG. 4, the virtual objects can be located anywhere in space."), 8:65-10:2 (describing a 3D environment that includes virtual objects), 10:3-32 ("In one embodiment, game console 422 tracks the location of the ears of player 406 a. When sounds are generated in the game (e.g., the sound of a helicopter flying) game console 422 determines the coordinates in the virtual space of the sound origin. Once the location of the ears and the location of the sound origin are known, the game console 422 determines the relative location between the sound origin and the ears perceiving the sound. Game console 422 also has information regarding the location of speakers 420 in the room. The HRTF of the user is used to convert the sound into a localized sound that appears to the user as coming from the sound origin. The localized sound, which is transmitted to speakers 420, includes different acoustic signals for each of the speakers 420 in order to simulate the location of the sound origin. The sound localization algorithm uses the HRTF of the user, as well as the current location of the user's ears to generate the localized sound for the earphones. The acoustic signals for the localized sound, which are played by the earphones, provide an acoustic clue to the user regarding the virtual location in space of the virtual object."), 10:33-11:3 ("For example, user 406 b has a game cannon, which is fired by the remote player. A sound effect simulates the fire of the cannon from the actual location of user 406 b. The firing shot is heard first, and is followed by the sound of the cannonball as the cannonball travels through the air from the location of player 406 b to the location of player 406 a. As the cannonball travels through the air, the sound increases in intensity, as in real life. Finally, the explosion is heard when the cannonball hits the target, and if the target is near the user, the sound will be delivered with high volume."), 12:15-27 ("FIG. 7 is a simplified schematic diagram of a computer system for implementing embodiments of the present invention. It should be appreciated that the methods described herein may be performed with a digital processing system, such as a conventional, general-purpose computer system. Special purpose computers, which are designed or programmed to perform only one function, may be used in the alternative. Computing device 712 includes a processor 732, which is coupled to memory 734, to permanent storage device 758, and to other modules inside, or connected to, computing device 712. Sound localization computer program 736 resides in memory 734, but can also reside in permanent storage device 758."), 12:47-55 ("Sound Projection module 716 modifies sound signals, intended for delivery to a sound system, in order to perform sound localization, such that the user receiving the modified sound signals will have the impression that the sound emanates from the intended location. Sound projection module 716 uses the location information provided by device position tracking module 724 and head tracking module 738 to modify the sound signals."), 12:55-67 ("It should



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be appreciated that processor 732 may be embodied in a general-purpose processor, a special purpose processor, or a specially programmed logic device."), Figs. 4, 7

- **Srinivasan** at 3:24-31 ("The user devices 102 and 104 may be any suitable device and may for example, be a mobile phone, a personal digital assistant ("PDA"), a personal computer ("PC") (including, for example, Windows™, Mac OS™ and Linux™ PCs), a tablet computer, a gaming device, a wearable device or other embedded device able to connect to the communication network 106. The wearable device may comprise a wearable headset"), 4:3-56 ("FIG. 2 illustrates a schematic view of the user device 102 on which is executed a communication client application for communicating over the communication system 100. The user device 102 comprises a central processing unit ("CPU") 202, to which is connected a display 204 such as a screen or touch screen, input devices such as a user interface 206 (for example a keypad), a camera 208, and touch screen 204. … The CPU 202 is connected to a network interface 224 such as a modem for communication with the communication network 106. The network interface 224 may be integrated into the user device 102 as shown in FIG. 2. In alternative user devices the network interface 224 is not integrated into the user device 102. The user device 102 also comprises a memory 226 for storing data as is known in the art. The memory 226 may be a permanent memory, such as ROM. The memory 226 may alternatively be a temporary memory, such as RAM."), 5:33-6:30 ("In one embodiment, shown in FIG. 3, the user device 102 is in the form of a headset or head mounted user device. The head mounted user device comprises a frame 302 having a central portion 304 intended to fit over the nose bridge of a wearer, and a left and right supporting extensions 306, 308 which are intended to fit over a user's ears. … The central portion 304 may house the CPU 303, memory 328 and network interface 324 such as described in FIG. 2."), 6:31-67 ("Furthermore the image or video may be augmented or annotated by the addition, deletion and interaction of objects. These objects or virtual objects can be 'placed' within the image scene and may have a visual representation which can be 'seen' and interacted with by the participants (including the scene owner). Objects may be defined not only by position but comprise other attributes, such as object type and state. The objects, for example, may have associated content such as audio/image/video/text content."), 10:1-46 ("Into this shared scene may be inserted an object such as an audio or video incoming call object which can be placed or pinned at a location within the shared scene. … The concept as described herein is to enable spatial audio signal processing to be performed on an audio signal associated with the object in such a manner that the audio signal appears to come from the approximate position of the object. This may be implemented for example by applying a suitable head related transfer function (HRTF) to an audio signal in the audio pipeline to produce a spatial output before being passed to the sound card and output."), 10:47-11:32 ("In the example shown in FIG. 5 there may further comprise an audio management entity 602. The audio management entity 602 may be configured to maintain or store audio processing parameters. For example the audio management entity may store initialisation information indicating the required output format (for example stereo, multichannel, 5.1 channel output.) Furthermore the audio management entity may store information such as initialisation parameters such as personalised HRTF's directivity patterns for the source and/or listener, and reverberation settings. The audio management entity 602 may be configured to output these parameters to the



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audio position processor 605."), 11:33-47 ("The example shown in FIG. 5 may further comprise an audio input buffer 603. The audio input buffer 603 may be configured to receive audio frames and buffer the audio frames prior to processing. In the example shown here in the audio input signal stream is a 16 bit floating point mono channel PCM encoded audio signal sampled at 48 kHz. However it is understood that the audio input may be any suitable audio input format. Furthermore it is understood that although for simplicity the examples shown and described herein feature a single object and audio data associated with the object that the methods and apparatus may be configured to process multiple objects and audio signals. In such embodiments the output of each of the audio signals may be combined to generate a combined processed object audio signal."), 11:48-12:11 ("The audio input buffer 603 may be convicted to pass the input audio signal to the audio position processor 605. The example shown in FIG. 5 further comprises an audio position processor 605 (or audio signal processor or spatial audio signal processor). In such embodiments the audio position processor 605 may be configured to receive the input audio signal from the audio input buffer 603, the relative position/orientation information from the relative position/orientation determiner 601 and the configuration data from the audio management entity 602. The audio position processor 605 may then generate a suitable processed audio signal output. For example in some embodiments the audio position processor may be configured to apply a head related transfer function (HRTF) using the relative position/orientation information as an input parameter to generate multiple audio output channels from a mono audio input channel. In the example described herein the audio positional processor 605 may generate a 16 bit floating point stereo PCM audio signals sampled at 48 kHz to an audio output buffer 607. In the example shown herein the audio position processor 605 uses a HRTF to generate the multiple channel audio output signals. However any suitable spatial processing application may be employed to generate the audio signals. For example the spatial processing may be amplitude panning or mapping of the mono audio signal to the output channels. The example shown in FIG. 5 furthermore comprises an audio output 607 configured to receive the audio signals output from the audio position processor 605, buffer and output the audio to a suitable audio output entity, for example a soundcard within a personal computer or similar digital-to-analogue conversion entity."), 12:12-24 ("With respect to FIG. 6 a flow diagram 700 of an example initialization process associated with the example implement patient shown in FIG. 5 is described. The initialization process may for example start with the setting of an initial source position. This initial source position may be a default object position stored within the audio management entity 602. In some examples of the initial source position can default to an initial coordinate system of (0,0,0)."), 12:47-13:60 ("The audio position processor 605 may then receive the audio input signals and apply suitable head related transfer function processing using the relative listener-source values as the input parameter to the HRTF to generate suitable audio channel outputs. For example the audio position processor 605 may generate stereo audio channels from the mono input audio channel. The process of generating stereo (multiple) audio channels from a mono audio channel using the head related transfer function is a known method and not described in any further detail herein. The operation of generating stereo or multichannel audio signals using a HRTF



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with relative listener-source values is shown in FIG. 7 by step S811."), Figs. 2, 3, 5. 6, 7.

- **Sauk 903** at 11:26-41 ("The selective filtering techniques described above can be utilized by BSS 400 in another configuration which combines a plurality of audio dimensions such as 3-D (binaural), 2-D (stereophonic), and 1-D (monophonic). For example, in certain circumstances, a user may not want to eliminate all background audio information. However, rather than keeping the less relevant audio in the same audio dimension with their desired binaural sound sources, a user could change the less relevant audio to a monophonic (1-D) or stereophonic (2-D) dimension. The effect of changing an audio format for sounds from binaural to monophonic or stereophonic audio signifies a different level of relevancy or importance for such audio. This process also removes any localization cues for that audio. The decibel level of the 1-D, 2-D or 3-D audio can be adjusted to whatever the listener desires for that dimension."), 10:32-12:51 (describing selective filtering mode and selective relevance mode).

### 9. Image rendering in relation to a sound source

Method for rendering images in relation to a sound source were well known to a POSA at or before the purported priority dates of the Asserted Claims. Illustrative examples of such methods are disclosed in at least the following:

- **Billinghurst 1998** at 5 ("With this display configuration a wearable conference space could be created that allows remote collaborators appear as virtual avatars distributed about the user (figure 2.0). The avatars could be live video streams and as they speak their audio streams spatialized in real time so that they appear to emit from the corresponding avatar.")
- **Jang** at 6:39-59 ("Upon receiving the virtual reality space information, the control unit 114 may access the storage unit 102 to access audio, sound, and/or other sensory data to output to the user to represent the virtual environment. According to the present embodiment, the control unit 114 may control the sensory data to correspond to the virtual environment. The control unit 114 may mix sensory data of the virtual environment including a user's avatar or character and other avatars, characters, objects, or features of the virtual environment. The control unit 114 may divide the sensory data into a focus area and non-focus areas and may control the sensory processing unit 118 to output sensory elements of the focus area differently than sensory elements of the non-focus areas. For example, the control unit 114 may instruct the sensory processing unit 118 to cause audio elements of the non-focus areas to be muffled or quieter than audio elements of a focus area. In the case of *visual sensory elements*, the control unit 114 may instruct the sensory processing unit 118 to cause visual elements of non-focus areas to be less clear, blurred, or dark and visual elements of the focus area to be detailed and clear.")
- **Etter 419** at [0032] ("Note that only the auditory locations of sound source locations 51 (S) and 52 (S*) are shown in the figure, without their corresponding visual locations



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being shown. (The actual visual locations will, for example, differ for 2D and 3D displays.) Note also that the person creating sound at sound source location 52 (S*) will, in fact, visually appear to observer 54 on the screen of video display 53, even though, assuming that angle γ is used as described above with reference to FIG. 4, the sound source itself will arrive from outside the visual area. This will disadvantageously produce an apparent mismatch between the visual and auditory space. Similarly, the sound source S will also be mismatched from the corresponding visual representation of the speaker.")

- **Flaks 968** at 4:10-13 ("To the listener 8, the sound in the 3D audio signal may appear to be originating from some virtual sound source 29. As one example, the virtual sound source 29 a could be an object being displayed on the display 196."), 9:4-10 ("FIG. 5A is a flowchart of one embodiment of a process 500 of determining components for a 3D audio signal. Process 500 is one embodiment of step 306 of process 300. In step 502, the location of a virtual sound source 29 is determined. For example, if a user is interacting with a virtual world depicted on a display 196, then the virtual sound source 29 could be some object being displayed in that virtual world."), Fig. 5A
- **Otto 440** at 11:2-13 ("As an example of a spatialized sound application, FIG. 7b illustrates a hypothetical video conference call with multiple parties at multiple locations. When the party located in New York is speaking, the sound is delivered as if coming from a direction that would be coordinated with the video image of the speaker in a tiled display 18. When the participant in Los Angeles speaks, the sound may be delivered in coordination with the location in the video display of that speaker's image. On-the-fly binaural encoding can also be used to deliver convincing spatial audio headphones, avoiding the apparent mis-location of the sound that is frequently experienced in prior art headphone set-ups."), Figs. 7a, 7b
- **Nystrom** at 6:27-33 ("Speaker 302 may provide audible information to a user of user device 204. Display 304 may provide visual information to the user, such as an image of a caller, video images received via cameras 310/312 or a remote device, etc. In addition, display 304 may include a touch screen via which user device 204 receives user input. The touch screen may receive multi-touch input or single touch input.")
- **Craner** at 24:57-25:15 ("One embodiment of an interface could include a three dimensional representation of the talkers located about a conference table, or in a similar setting. The interface would allow for the selection of an appropriate emotigraphic for each one of the talkers (male, female, heavy, thin, etc.). The display for each emotigraphic could optionally have a name or other information fields displayed below the emotigraphic. During operation, as one of the talkers speaks, the corresponding emotigraphic is highlighted in some fashion. Optionally, the emotigraphic includes facial and body animation associated with the act of speaking. The emotigraphics could include photographic images of portions of the talkers (e.g., the faces). The photographs of the talkers can be integrated if the photographs are provided in advance and the software may optionally support conformal mapping of the photographs to the optionally three dimensional computer emotigraphic forms, or primitive implementations can utilize 2D facial overlay with other embodiments also including facial morphing to effect lip, eye and facial muscle movements.



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Emotigraphics may undergo a variety of motions including, but not limited to: animating, highlighting, enhancing, embellishing with text, blinking, morphing, flipping, rotating, changing the color of, changing the intensity of, animating the subcomponents of, changing the apparent emotional state of, and animating the mouth of the talker."), Figs. 12-14.

- **Begault 2000** at 99-100 ("Nonindividualized HRTFs result in poorer localization than individualized HRTFs, but the latter are usually impractical for use in most applications. Under optimal conditions--individualized HRTFs, broadband signal, and target positions at lower elevations (eye level and below)--the localization error for virtual images is only slightly greater differences between individuals. The perception of virtual sound sources is significantly affected by the inclusion of reverberation. Reverberation enables externalization of images outside the head, allows a sense of the surrounding environmental context, and is a cue to distance when used in terms of the R/D ratio.")
- **Haddick 248** at [00650] ("In embodiments, the user may be able to control their view perspective relative to a 3D projected image, such as a 3D projected image associated with the external environment, a 3D projected image that has been stored and retrieved, a 3D displayed movie (such as downloaded for viewing), and the like. For instance, and referring again to Fig. 15C, the user may be able to change the view perspective of the 3D displayed image 1512C, such as by turning their head, and where the live external environment and the 3D displayed image stay together even as the user turns their head, moves their position, and the like. In this way, the eyepiece may be able to provide an augmented reality by overlaying information onto the user's viewed external environment, such as the overlaid 3D displayed map 1512C, the location information 1514C, and the like, where the displayed map, information, and the like, may change as the user's view changes. In another instance, with 3D movies or 3D converted movies, the perspective of the viewer may be changed to put the viewer 'into' the movie environment with some control of the viewing perspective, where the user may be able to move their head around and have the view change in correspondence to the changed head position, where the user may be able to 'walk into' the image when they physically walk forward, have the perspective change as the user moves the gazing view of their eyes, and the like. In addition, additional image information may be provided, such as at the sides of the user's view that could be accessed by turning the head."), Fig. 15C.
- **Gardner** at 3:16-29 ("More generally, the present invention relates to audio teleconferencing systems that recreate a sound-field effect of participants in a shared acoustical space. In embodiments involving the application of spatial audio teleconferencing to networked virtual environments, each participant controls a representation of himself or herself in a 3-D virtual world. The virtual world can be created for game play, social interaction, or business collaboration. Embodiments of the invention allow participants in the virtual world to converse with other participants while recreating the acoustics of the virtual world, including localization cues, reverberation, and other environmental audio effects. Participants may converse naturally with other participants who are proximate in the virtual world.").
- **Zhou** at 1047 ("In our first experiment, the sound sources are always placed around



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1.5 m away in the front of the listener. However, in a more general and complex AR environment like the second experimental environment, the listener can walk freely in a physical space where virtual sound sources can be very close to the left and the right side of the head."), 1054 ("As shown in Fig. 4, we augmented the same shape virtual telephone with a different color on each of the markers. The virtual telephones were augmented with a 3D telephone sound that was produced to emanate from each virtual telephone."), 1059 ("Our experimental system allows two users to play a simple game at the same time. The objective of this game is to rescue the princess who was captured by an evil witch. In this experimental game, three stages were used to for investigating the effects of 3D sound. In the first stage, users are allowed to walk around in a 3 m by 3 m region and to explore a virtual land augmented on the physical ground through a small rectangle virtual window displayed on the tracked wand. Fig. 9 shows the scrolling 3D landscape when the player is moving her hand. A small virtual plane is attached to the wand as an avatar for the user, as if the user is exploring the game space by manipulating the plane. The player is looking for the castle through the 'magic 3D window'. Two 3D sounds are applied in this stage and can be heard by both players."), Fig. 4

- **Kim 417** at [0006] ("The conventional augmented reality technologies usually have focused upon visual aspect technologies which synthesize virtual images onto real images of real world. However, in a case that the HMD comprises an audio outputting unit, it can provide the user with the auditory augmented reality as well as the visual augmented reality. In this case, a technology for realistically augmenting virtual audio signals is needed."); [0065] ("Meanwhile, according to another exemplary **embodiment**, the HMD 100 may obtain a position of a virtual sound source of the virtual audio signal 60. The position of the virtual sound source may be indicated by the user wearing the HMD, or obtained together with additional information when obtaining the virtual audio signals. The HMD may be configured to convert the virtual audio signal into a three dimensional (3D) audio signal based on the obtained position of the virtual sound source. In a case that the audio output unit of the HMD 100 includes a two-channel stereo output unit, the HMD 100 may be configured to make a sound image of the virtual audio signal 60 be oriented toward the position of the virtual sound source. In the exemplary embodiment of FIG. 6, the virtual sound source of the virtual audio signal 60 is assumed to be located in the right-back side of the string quartet payers. Thus, the HMD 100 can provide the user 10 with a virtual experience in which the flute is being played in the right-back side of the string quartet players."); [0077] ("As illustrated, the user may be provided with a content 30 through the HMD 100. The contents 30 may include various contents such as movie, music, document, video call, navigation information, etc. In a case that the content 30 includes image data, the HMD 100 may output the image data to the display unit 120. Also, voice data of the content 30 may be outputted to the audio output unit of the HMD 100. The HMD 100 may receive a real sound in surrounding areas of the HMD 100, and extract spatial audio parameters based on the received real sound. Also, the HMD 100 may filter the audio signal of the content 30 by using the extracted spatial audio parameters, and output the filtered audio signal.")



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### 10. Virtual rooms

Virtual rooms and systems and methods for implementing the same were well known to a POSA at or before the purported priority dates of the Asserted Claims. Illustrative examples of such virtual rooms and systems and methods for implementing the same are disclosed in at least the following:

- **Billinghurst 1998** at 5 ("With this display configuration a wearable conference space could be created that allows remote collaborators appear as virtual avatars distributed about the user (figure 2.0). The avatars could be live video streams and as they speak their audio streams spatialized in real time so that they appear to emit from the corresponding avatar.")
- **Otto 440** at 11:2-13 ("As an example of a spatialized sound application, FIG. 7b illustrates a hypothetical video conference call with multiple parties at multiple locations. When the party located in New York is speaking, the sound is delivered as if coming from a direction that would be coordinated with the video image of the speaker in a tiled display 18. When the participant in Los Angeles speaks, the sound may be delivered in coordination with the location in the video display of that speaker's image. On-the-fly binaural encoding can also be used to deliver convincing spatial audio headphones, avoiding the apparent mis-location of the sound that is frequently experienced in prior art headphone set-ups."), Figs. 7a, 7b
- **Ballas 439** at 1:47-58 ("Possible applications of spatial audio processing techniques include: Military communication systems to and between individuals within military vehicles, ships and aircraft as well as to and between dismounted soldiers; complex supervisory control systems such as telecommunications and air traffic control systems; complex supervisory control system such as telecommunications and air traffic control systems; civil and military aircraft warning systems; teleconferencing and telepresence applications; virtual and augmented reality environments[.]").
- **Flaks 968** at 4:10-13 ("To the listener 8, the sound in the 3D audio signal may appear to be originating from some virtual sound source 29. As one example, the virtual sound source 29 a could be an object being displayed on the display 196."), 9:4-10 ("FIG. 5A is a flowchart of one embodiment of a process 500 of determining components for a 3D audio signal. Process 500 is one embodiment of step 306 of process 300. In step 502, the location of a virtual sound source 29 is determined. For example, if a user is interacting with a virtual world depicted on a display 196, then the virtual sound source 29 could be some object being displayed in that virtual world."), Fig. 5A
- **Jarvinen** at 26:30-59 ("For purposes of illustration and not of limitation, consider an example in which a user is participating in a teleconference or listening to music. In this example, presume that Peter (e.g., a fictitious person) is participating in a spatial audio teleconference (or is listening to music) using a smartphone (e.g., apparatus 50) with a headset/headphones while Anna (e.g., another fictitious person) suddenly enters the room. When Peter notices Anna entering the room and Anna desiring to speak with



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him, Peter may make a gesture with his hand (or with the smartphone) on an audio object(s) (e.g., sound from a speaker) in the direction of Anna and may instantly reduce the volume of the audio object(s) so that he can hear what Anna is saying while still being able follow the teleconference (or listen to the music) uninterrupted. Later, there may be a sudden loud noise in the surroundings preventing Peter from hearing speakers (or musical instruments) in the direction of the noise. By utilizing an example embodiment, Peter may instantly increase the sound volume of an audio object(s) (e.g., a speaker(s)) located in the direction of the noise, and may re-position the audio object elsewhere in the 3D audio space to minimize the impact of the noise disturbing the listening experience. As such, an example embodiment enables easy, quick and natural manipulation of surround sound audio since the user may manipulate the spatial audio the user is listening to with clear association between actions of the user in the physical space around the user and the spatial audio around the user. This enables instant manipulation of the audio objects and as such the user is able to interact quickly and precisely with audio objects.").

- **Pedersen** at 13:14-24 ("The upper part of FIG. 1 schematically illustrates a meeting in which one of the participants 100 uses a new hearing device system (not visible) comprising a binaural hearing aid (not visible) and his or her smartphone 110 controlling the binaural hearing aid and illustrated in the lower part of FIG. 1. The other meeting participants 102, 104, 106 wear spouse microphones (not visible) that transmit speech from the respective meeting participants to the binaural hearing aid of participant 100. Further, a participant in a remote location also participates in the meeting using a teleconference system (not shown).").
- **Etter 419** at [0053] ("FIG.8 shows an illustrative environment for providing binaural audio-visual rendering of a sound source in a video teleconferencing application using a video display screen and a dummy head in the subject conference room, in accordance with a fourth illustrative embodiment of the present invention. The figure shows two rooms—conference room 801 and remote room 802. Remote room 802 contains remote participant 812 who is viewing the activity (e.g., a set of conference participants) in conference room 801 using video display screen 811 and listening to the activity (e.g., one or more speaking conference participants) in conference room 801 using a headset comprising right speaker 809 and left speaker 810."), Fig. 8.
- **Boustead** at 7:14-28 ("The conference server 110 may e.g. be an application server of an audio conference service provider within a telecommunication network. The terminals 120 may e.g. be computing devices, such as laptop computers, desktop computers, tablet computers, and/or smartphones; as well as telephones, such as mobile telephones, cordless telephones, desktop handsets, etc. . . . . The conference server 110 comprises a central conference controller 111 configured to combine the plurality of upstream audio signals 123 to from an audio conference. The central conference controller 111 may be configured to place the plurality of upstream audio signals 123 at particular locations within a 2D or 3D conference scene and generate information regarding the arrangement (i.e. the locations) of the plurality of upstream audio signals 123 within the conference scene.")



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- **Knappe** at 1:65-2:3 ("The present invention takes advantage of the signal processing capability present at either a central MCU or at a conferencing endpoint to add directional cues to the voices present in a conference call. In several of the disclosed embodiments, a conferencing endpoint is equipped with a stereo (or other multichannel) audio presentation capability.")
- **Begault 2000** at 182 ("The gain and azimuth heard for each icon is linked to the relative position on the graphic display; a mouse can be used to make sources louder by resizing the icon. MAW allows teleconference participants to wander around in the virtual room and to focus their voice toward particular conference participants by using a binaural HRTF to process each virtual source. Distance cues also are modeled in the system, and one can leapfrog between teleconference sessions or be at several simultaneously simply by cutting and pasting one's personal graphic icon to different environments, each represented by a separate window. One can also move to a "private conference" by moving the icons of the participants to a special region on the computer screen, symbolized as a separate room.")
- **Bedingfield** at 3:25-34 ("An improved telephone or network-based communication system may more closely simulate an in-person conference setting. For example, a communication system may provide multi-channel sound to a listener by modifying a single channel signal provided by another participant's system. To further enhance the listener's experience, the communication system may assign each participant a virtual position within a virtual sound field. Each participant is heard by the listener in multi-channel audio based on the participant's virtual location in the sound field."), 5:4-10 ("FIG. 2 is a block diagram of a method 200 for providing synthetic audio placement and how participants may be connected to one another. At a block 202, the method 200 begins. At a block 204, a listener is connected. At a block 206, a first participant is connected with the listener from the block 204. For example, the listener 102 is connected to the participant 104 as shown in FIG. 1."), Fig. 2.
- **Hammershoi** at [0062] ("Since the position of the listener's ears is known, it is possible to synthesize a virtual sound at a desired location relative to the listener. Such virtual sound may be used to make the listener part of a teleconference still walking around in a workplace. One distinct location in space relative to the listener can be used for each person participating in the teleconference, thus improving speech intelligibility even if the listener is still capable of noticing calls or warning signal in the workplace environment.")
- **Curry** at 7:29-52 ("FIG. 2 shows a schematic of a spatial sound conference bridge used in a spatial sound conference system. As an alternative to use of a dummy head to capture spatialized sound components for right and left audio signals, a spatial sound conference bridge may be used to convolve head-related transfer functions with a monaural signal to create spatial signals. In a teleconference situation with single participants at multiple sites, a spatial sound conference bridge 200 containing a head-related transfer function unit 205 can be used to create a spatial sound conference system. In a preferred embodiment, the spatial sound conference bridge 200 receives a digital monaural signal via either B-channel from each conference participant station at ports 201, 202, 203, 204 connected to ISDN lines having 2 B-channels and a D-



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channel. The monaural signal may be either compressed or uncompressed depending upon the available bandwidth. If the incoming monaural signal is compressed, individual decompression unit 225 could be used to decompress the incoming signal. If one or more participants does not have a digital line to the conference bridge, an A/D conversion unit 230 in spatial sound conference bridge 200 could be used to digitize the incoming signal in preparation for convolution by the head-related transfer function unit 205."), Fig. 2.

- **Nystrom** at 5:27-45 ("User device 204 may include any of the following devices to which earphones may be attached (e.g., via a headphone jack): a personal computer; a tablet computer; a cellular or mobile telephone; a smart phone; a laptop computer; a personal communications system (PCS) terminal that may combine a cellular telephone with data processing, facsimile, and/or data communications capabilities; a personal digital assistant (PDA) that includes a telephone; a gaming device or console; a peripheral (e.g., wireless headphone); a digital camera; or another type of computational or communication device. Via user device 204, a user may place a telephone call, text message another user, send an email, etc. In addition, user device 204 may receive and store computed HRTFs from HRTF device 206. User device 204 may use the HTRFs to generate signals to drive earphones 110 to provide stereo sounds. In generating the signals, user device 204 may apply intensity panning, to be described below, based on HRTFs stored on user device 204.")
- **Craner** at 17:12-21 ("In voice/video teleconferencing applications, spatialization provided by at least two-dimensional spatialization equipment processing at both the voice capture device 300 and the voice-projecting device 400 allows for the relative locations of the different talkers to be accurately reflected (both in voice and in video) to the listener. However, if a listener voice calibrator at the voice projecting device 400 is to accurately spatially separate the voices of the different talkers, the spatial equipment must be provided at both the voice projecting device and at the voice capture device.").
- **Gardner** at 3:16-29 ("More generally, the present invention relates to audio teleconferencing systems that recreate a sound-field effect of participants in a shared acoustical space. In embodiments involving the application of spatial audio teleconferencing to networked virtual environments, each participant controls a representation of himself or herself in a 3-D virtual world. The virtual world can be created for game play, social interaction, or business collaboration. Embodiments of the invention allow participants in the virtual world to converse with other participants while recreating the acoustics of the virtual world, including localization cues, reverberation, and other environmental audio effects. Participants may converse naturally with other participants who are proximate in the virtual world.")
- **Li 305** at 21:57-22:5 ("Therefore, the configurable 3D sound system 900 disclosed herein allows music artists to present their music to the user in an enhanced manner, and also enhances the performance of radio dramas and conference calls. The 3D binaural sound recording performed by the configurable 3D sound system 900 disclosed herein provides special effects and acoustic experiences to a user, for example, by allowing the user to move the sound source around the user 1703, move



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the sound source up and down, etc., on the configurable sound field 1700. The configurable 3D sound system 900 enhances the dramatic performance of radio drama shows and podcasts. Moreover, the configurable 3D sound system 900 provides a method of communication among multiple people, for example, in a conference call, by placing different speaking users at different spots to mimic a real conference room environment.")

- **Zhou** at 1047 ("In our first experiment, the sound sources are always placed around 1.5 m away in the front of the listener. However, in a more general and complex AR environment like the second experimental environment, the listener can walk freely in a physical space where virtual sound sources can be very close to the left and the right side of the head."), 1054 ("As shown in Fig. 4, we augmented the same shape virtual telephone with a different color on each of the markers. The virtual telephones were augmented with a 3D telephone sound that was produced to emanate from each virtual telephone."), 1059 ("Our experimental system allows two users to play a simple game at the same time. The objective of this game is to rescue the princess who was captured by an evil witch. In this experimental game, three stages were used to for investigating the effects of 3D sound. In the first stage, users are allowed to walk around in a 3 m by 3 m region and to explore a virtual land augmented on the physical ground through a small rectangle virtual window displayed on the tracked wand. Fig. 9 shows the scrolling 3D landscape when the player is moving her hand. A small virtual plane is attached to the wand as an avatar for the user, as if the user is exploring the game space by manipulating the plane. The player is looking for the castle through the 'magic 3D window'. Two 3D sounds are applied in this stage and can be heard by both players."), Fig. 4

### 11. Microphones

Microphones were well known to a POSA at or before the purported priority dates of the Asserted Claims. Illustrative examples of such microphones are disclosed in at least the following:

- **Andrea** at 2:37-40 ("A further object of the invention is to provide for a stereo headset or stereo earbuds with an integrated array of microphones utilizing an adaptive beam forming algorithm."), 10:35-50 ("The invention according to an embodiment may be an integrated headset system 200, a highly directional stereo array microphone with reception beam angle pointed forward from the ear phone to the corner of a user's mouth, as shown in FIG. 8. As shown in FIG. 8, headset system 200 is a circumaural headset. In some embodiments, a supra-aural headset using headphones 302 (shown in FIGS. 12 a-b), earbuds 303 (shown in FIG. 13), and/or one or more earphones may be utilized. The pick-up angles or the angles in which the microphones 250 pick up sound from a sound source 210 is shown in FIG. 9( d), for example, in front of the array, while cancellation of all sounds occurs from side and back directions. Different views of this pick-up 'area' 220 are shown in FIGS. 9( a)-9(c). Cancellation is approximately 30 dB of noise, including speech noise."), 14:44-61 ("As noted above, in one embodiment, the audio transmitting/receiving device may be, for example, a pair of earbuds. In this embodiment, each earbud may include one or more audio receiving means (e.g.,



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microphone(s)). Positioning audio receiving means on each earbud creates a dual-channel audio reception device that may be used to create desirable audio effects. For example, this embodiment may be advantageously used to produce a surround sound effect. Such a surround sound effect is made possible by virtue of the audio receiving devices being positioned on each side a user's head during operation. While a user is wearing the earbuds, the audio receiving means on each earbud may pick up the same sound emanating from a single sound source (i.e., the respective audio receiving means may create a binaural recording). Because of the spatial discrepancy between each of the audio receiving means, a distinct audio signal may be produced in each of the channels corresponding to the same sound."), Figs. 2, 8, 9(a)-(d), 12(a)-(b), 13, 28

- **Bedingfield** at 4:7-12 ("Therefore, the multi-channel audio communication system may render single channel sound detected by a speaker's microphone into a synthetic audio placement allowing a listener to sense the location (within the sound field) of the speaker through the modified audio signal presented to the listener.")
- **Flaks 968** at 4:21-26 ("In some embodiments, the user "wears" one or more microphones 31, which may be used by the system 10 to determine acoustic properties of the room to provide a more realistic 3D audio signal. In this example, the microphones 31 are located on the headphones 27, but the user could "wear" the microphones 31 in another location. In some embodiments, the user "wears" one or more inertial sensors 38, which may be used by the system 10 to determine location and rotation of the listener 8. In this example, the inertial sensor 38 is located on the user's head but the user could "wear" the inertial sensor 38 in another location. For example, the inertial sensor 38 could be integrated into the headphones 27. In some embodiments, the user 8 may carry a camera, which may be used to provide the system 10 with depth and/or RGB information similar to that generated by the depth camera system 20.")
- **Pedersen** at 13:14-24 ("The upper part of FIG. 1 schematically illustrates a meeting in which one of the participants 100 uses a new hearing device system (not visible) comprising a binaural hearing aid (not visible) and his or her smartphone 110 controlling the binaural hearing aid and illustrated in the lower part of FIG. 1. The other meeting participants 102, 104, 106 wear spouse microphones (not visible) that transmit speech from the respective meeting participants to the binaural hearing aid of participant 100. Further, a participant in a remote location also participates in the meeting using a teleconference system (not shown)."), *id.* at 18:32-43 ("In FIGS. 2, 3, and 4, the dashed lines indicate the housings of the first and second hearing aids 10A, 10B accommodating the components of the binaural hearing aid 10A, 10B. Each of the housings accommodates the one or more microphones 12A, 12B for reception of sound at the respective ear of the user for which the respective hearing aid 10A, 10B is intended for performing hearing loss compensation, and the respective receiver 42A, 42B for conversion of the respective output signal 40A, 40B of the signal processor 18 into acoustic signals for transmission towards eardrum of the respective one of the right and left ears of the user."), Figs. 2, 3, and 4.
- **Hammershoi** at [0033] ("The system may further include first and second microphones arranged for position at ear canal reference points for the binaural audio data. The first



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and second microphones are preferably arranged for position at entrances to the respective ears of the listener. The first and second microphones are preferably included in respective first and second earphone parts arranged for position in respective ears of the listener.")

- **Curry** at 3:51-4:5 ("FIG. 1 shows a schematic of a spatial sound conference system using a dummy head in a conference room that transmits spatial sound to a participant at a remote location across ISDN facilities. Inside conference room station 100 is a dummy head 101 having at least two spatially disposed microphones 103, 105 placed at the right and left ear locations. The dummy head 101 may also contain a loudspeaker 107 at the mouth location, or a loudspeaker may be placed near the dummy head. The dummy head may also include shoulders or a torso. Advantageously, the dummy head may be placed directly on conference table 120 or on a chair in the conference room station or otherwise spatially situated at a conference location. Other conference participants may be situated about the conference room station, preferably equally spaced around conference table 120. According to an advantageous feature, the specialized equipment at conference room station 100 may be kept to a minimum. Alternatively, the conference room station may be designed as rooms for audiovisual conferences, long distance learning system classrooms, or virtual reality booths with the attendant equipment necessary for such applications."), Fig. 1.
- **Knappe** at 3:47-52 ("Microphones 20L and 20R simultaneously capture the sound field produced at two spatially separated locations when B1, B2, or B3 talk, translate the captured sound field to electrical signals, and transmit those signals over left and right capture channels 22L and 22R. Capture channels 22L and 22R carry the signals to encoder 24."), Fig. 1.
- **Li 305** at 4:6-16 ("The microphone is positioned in an ear canal of each of the ears of the simulator apparatus. The 3D sound processing application is executable by at least one processor configured to measure head related transfer functions, to simultaneously generate configurable three-dimensional (3D) sounds in communication with a microphone array system, to simultaneously generate configurable 3D sounds using pre-recorded sound tracks and pre-recorded stereo sound tracks, to generate a configurable 3D binaural sound from a stereo sound or a multi-channel sound, and to generate a configurable 3D surround sound.")
- **Ballas 439** at 1:47-58 ("Possible applications of spatial audio processing techniques include: Military communication systems to and between individuals within military vehicles, ships and aircraft as well as to and between dismounted soldiers; complex supervisory control systems such as telecommunications and air traffic control systems; complex supervisory control system such as telecommunications and air traffic control systems; civil and military aircraft warning systems; teleconferencing and telepresence applications; virtual and augmented reality environments[.]").

### 12. Applications for use with wearable devices

Applications for use with wearable devices were well known to a POSA at or before the purported priority dates of the Asserted Claims. These applications vary in content, but include,



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for example, social platforms facilitating interaction among remote users, games involving tasks for users to accomplish, and world exploration or building where users manipulate the environment. Also well known to a POSA are development kits or engines that developers use to create or modify interactions or gameplay within these applications. Illustrative examples of such microphones are disclosed in at least the following:

- **Audio Spatializer SDK (Unity 5.3)** at Overview ("The audio spatializer SDK is an extension of the native audio plugin SDK that allows changing the way audio is transmitted from an audio source into the surrounding space. The built-in panning of audio sources may be regarded as a simple form of spatialization in that it takes the source and regulates the gains of the left and right ear contributions based on the distance and angle between the AudioListener and the AudioSource. This provides simple directional cues for the player on the horizontal plane."), SDK and Example Implementation ("We found that the best way to support these in Unity was to create an open interface, the Audio Spatializer SDK, which is an extension on top of the Native Audio Plugin SDK that allows replacing the standard panner in Unity by a more advanced one and gives access to important meta-data about the source and listener needed for the computation.")
- **RealSpace3D Audio Unity Plugin Beta Version** at 11 ("A single instance of the RS3D AudioListener must be added to the main camera or a camera that controls the player (see 2.1). If you are using a Head Mounted Display (HMD) camera that has left, middle, and right cameras, it is best to place the RS3D AudioListener on the middle camera. If a stereo camera with left and right, either camera will do."), 12-13 ("HRTF Setting: A selection to choose from different types of HRTFs. HRTFs are used to spatialize the sound so that you hear audio in 3D. Try them out and select the best that works for you. The Default is what works for 80% of the population."), 24 ("The RS3D Audio HRTF entry box enables developers to expose to their end-users the ability to choose the HRTF they wish to hear RS3D Audio with. The user can choose from the VisiSonics' set of HRTFs or if they have a personalized HRTF they can enter the file or url received from VisiSonics."), 14 ("The RS3D AudioSource is the component that you will place on game object that you wish to emit 3D audio from (see 2.2). You can also just place a RS3D AudioSource into a scene without it being associated to an obje[c]t; this is a good approach for ambient sounds or sounds you just do not wish to associate with an object. The choice is yours.")
- **VRChat:** "VRChat v0.1 Released" Reddit post ("I'm the developer of VRChat, the virtual reality meeting space, and I have some great news! VRChat v0.1 is now available for download! The application is still in its VERY early stages and bugs may be found … Features: Virtual coffee shop environment; Anybody can host a server/create a "room" up to 16 people; Private rooms, secured by a password; Networked Avatars (no animations yet); 3D Voice Chat (Hold "V" to talk); Name Tags;



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Both Rift and Non-Rift Compatible"); VR Chat Review (Feb. 28, 2015) video (showing different avatars moving around and speaking with each other)

- **Second Life:** Oculus Rift Release Notes 3.7.8 ("- Align to look - [ "Q" ] To change the direction you are walking to match the direction you are looking press the "Q" key … - HMD Mode - [CTRL + SHIFT D ] To activate the Oculus Rift choose "Display Select" from the "me" drop down. You can also press "CTRL+SHIFT D" or click the "Display Select" button on toolbars if you add it to your layout. This command also allows one to display the stereo rendering output intended for the Oculus Rift on their primary display."); "Using the Oculus Rift with Second Life" press release ("The Project Viewer features: Full Oculus Rift Hardware Support - includes automatic hardware detection and display calibration for quick and easy setup. Full UI Support - users can access the entire Second Life UI and HUDs while in Oculus Rift mode, so there are no limitations on what a user can do inworld while using the headset. Customizable UI - users can tailor the settings for Oculus Rift mode that work best for their needs. Avatar Head Motion - Oculus Rift head-tracking data is mapped to the avatar, so users' avatars look where they do. New First-Person View - allows users to enjoy the immersion previously available with mouselook mode, but thanks to the Oculus Rift, the mouse is free again to control the cursor, allowing for interaction with the UI and objects inworld. "Align to Look" - allows users to quickly start moving the direction they are looking. "Action Key" - interact with objects by pressing a key, works great in mouselook mode."); "Oculus Rift DK2 Project View Now Available" press release ("A few months ago, we released a Project Viewer that made it possible to use the first generation Oculus Rift development kit (DK1) anywhere in Second Life. Since then, Oculus Rift has released a second generation development kit, DK2. The new hardware offers an even more immersive experience when used with Second Life - there's less likelihood of feeling motion sick thanks to the motion-tracking features, and less of the "screen-door effect" on the visuals, thanks to higher resolution and brighter display."), Second Life Wiki "Environment Sounds" ("llPlaySound(): Attached - sounds follow the object they are in if it moves.")
- **Project Sansar:** Project Sansar Testing press release ("Slated for general availability in 2016, Project Sansar will democratize virtual reality as a creative medium. It will empower people to easily create, share, and monetize their own multi-user, interactive virtual experiences, without requiring engineering resources. The platform will enable professional-level quality and performance with exceptional visual fidelity, 3D audio, and physics simulation. Experiences created with Project Sansar will be optimized for VR headsets like the Oculus Rift, but also accessible via PCs and (at consumer launch) mobile devices. Users can explore and socialize within Project Sansar experiences through advanced expressive avatars, using text and voice chat. Drawing on more than 12 years of unique experience running Second Life, the largest-ever user-created virtual world, Linden Lab will make it fun and easy for Project Sansar users to create social VR experiences, eliminating the complicated challenges that today limit the medium to professional developers with significant resources. Project Sansar will allow creators at all levels to focus on realizing their creative visions, without having to worry about issues such as hosting and distribution, multi-user access and communication systems, virtual currency and regulatory compliance, and other challenges associated with



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creating, sharing, and monetizing virtual experiences today."); DIY VR – Ebbe Altberg (May 6, 2016) video (showing a user in a HMD moving around and moving objects to create a VR scene).

- **AltSpaceVR:** AltSpaceVR Documentation at 13 ("AltspaceVR is the leading platform for live mixed reality experiences. AltspaceVR allows artists, creators, brands, and businesses to create virtual events more easily. People from all over the world can use this social app to connect and collaborate in real time with a true sense of presence. Expressive avatars, engaging eye contact, spatial sound, and immersive virtual environments allow people to feel like they're together even when oceans apart. AltspaceVR is sitting at the intersection of experience, content, and community. It is the premier place for live concerts, conferences, comedy shows, festivals, tech talks, team meetings, remote collaboration, etc. AltspaceVR allows large groups of individuals to be co-present in a single space. FrontRow technology provides audience-scaling into the thousands."), 25 ("AltspaceVR is available for free on all major VR headsets: Oculus devices, HTC Vive, and Windows Mixed Reality (WMR)."), 28 ("MOVE AROUND – Walk, run, turn, shuffle, look around! Though movement itself feelssimilar in any VR headset, how you walk, run, turn, or throw a ball is device-specific. Tolearn how to control your avatar on your device or platform, please visit ourdocumentation for Oculus Quest, Windows Mixed Reality, and 2D PC. INTERACT WITH OBJECTS – Grip, grab, throw, and shoot things! And by shoot things, we don't just mean basketballs in a hoop (though you can do that). We also meanROCKETS. Yes, rockets. At skyscrapers. Or a blimp. (Fun, right??)"), 35 ("Worlds are pre-built VRenvironments that can range in size and scope from underwater cities to intergalacticlandscapes to public parks or mythical libraries. Some are built by our staff. Most ofthese Worlds are user-generated."), 36 ("Everyone in AltspaceVR has a Nametag. In addition to helping identify other users, its interface allows you to connect with people your vibe with and block or mute those you don't!")
- **CtrlAltStudio Viewer** at Softpedia article ("CtrlAltStudio Viewer is such a tool, which supports several gaming gadgets, including Oculus Rift and Microsoft Kinect devices. One of the great features of this application is the launcher. Thus, the application not only acts as a go-between hardware and software, but also streamlines the experience, providing users with a single launcher for multiple virtual worlds. The application supports several such games, including AviWorlds, UFSGrid, and Second Life … CtrlAltStudio Viewer allows one to have a high degree of control over the virtual experience. The application supports stereoscopic 3D display and variable walk and fly speeds, a good feature for new users. These things being said, it should be noted that some advanced customization features might not be available, especially in Second Life, as the application is based on the HAVOK library.")

### K. Additional Motivations to Combine

Combinations and modifications of the prior art discussed above, including references identified in the preceding Section (and similar references), invalidating the Asserted Claims would have arisen from ordinary innovation, ordinary skill, or common sense, or would have been



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obvious to try or otherwise predictable. In particular, it would have been obvious for a POSA to combine the teachings of the references identified in Sections IV.A - IV.I and IV.J to obtain the alleged inventions of the Asserted Claims for one or more of the following reasons: (1) the combination results from combining prior art elements according to known methods to yield predictable results, (2) the combination results from a simple substitution of one known element for another to obtain predictable results, (3) the combination results from the use of known techniques to improve similar methods in the same way, (4) the combination results from applying a known technique to a known method ready for improvement to yield predictable results, (5) the combination results from choosing a finite number of identified, predictable solutions, with a reasonable expectation of success, and therefore is obvious to try, (6) the combination results from known work in one field of endeavor prompting a variation of it for use in either the same field or a different one based on design incentives or other market forces and the variations would have been predictable to a POSA, or (7) the combination results from using known techniques or solutions to address a problem addressed by the alleged invention or a problem that would be encountered by a POSA working in the field.

Further, a POSA would have been motivated to combine the above-discussed prior art based on the nature of the problem to be solved, the teachings of the prior art, and the knowledge of a POSA. Design incentives and other market forces would have prompted such combinations and modifications. "When there is a design or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue known options within his or her technical grasp." *KSR Int'l*, 127 S. Ct. at 1742. Moreover, numerous references discussed above refer to or discuss other pieces of prior art cited in these contentions, illustrating the close technical relationship between such references. To the extent



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any piece of prior art refers to or discusses other pieces of prior art, either expressly or inherently, it would have been obvious to a POSA to combine those pieces of prior art for at least that reason. Additionally, a POSA would have known and been motivated to combine references discussed above because they relate to common objectives and subject matter and share commonalities in terms of general subject matter and the types of equipment, products, and approaches used. Moreover, numerous references cited herein share common authors or inventors, were published in the same journals, were presented at the same conferences, or were developed at common companies, educational or research institutions, or other organizations, all of which would motivate a POSA to combine them. In addition, to the extent the cited references, and any products, devices, or processes described in them, existed or were invented in the same time period, that provides further motivation for combination.

**1. The ’196 Patent**

A POSA developing a communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching interaction using a handheld portable electronic device where the user is able to issue commands. As discussed in the known art, it is important to provide the user with the ability to manipulate audio sources within a virtual environment, which would have otherwise been difficult to differentiate from other sound sources.

A POSA also would have had a reasonable expectation of success in incorporating interaction using a handheld portable electronic device because there are a variety of ways to implement a handheld portable electronic device for issuing commands to the system. The prior art discloses and teaches, for example, at least using a graphical user interface on a handheld tablet computer and hand gestures that the system interprets to move an avatar in the virtual world.



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As another example, a POSA developing a telephone communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching adjusting attenuation and reverberation of sound emitting from sound sources where the sound is artificial. Because a participant in a teleconference is exposed to multiple sound sources, it would have been obvious to incorporate the ability to modify attenuation and reverberation to differentiate said sound sources.

In addition, a POSA developing a telephone communication system would have been motivated to include spatial binaural audio or audio localization. For example, it was well-known in the art that spatial audio can be useful whenever a listener is presented with multiple auditory streams. Spatial audio requires information about the positions of all events that need to be audible, including those that would benefit from increased immersion in a virtual environment. Indeed, to a POSA, it would have been well-understood that binaural recordings sound more realistic as they are recorded in a manner that more closely resembles the human acoustic system. And therefore, using binaural audio increases user immersion and realism.

Additionally, a POSA developing a telephone communication system would have understood that many communication systems are limited to transmitting single-channel audio signals between users. Therefore, when conferences occur over typical communication systems, the spatial reference is often lost through single-channel communication. It is often difficult to determine which participant is speaking during a conference call when multiple participants sound similar or when there are many participants on the conference call. However, by integrating spatial binaural audio or audio localization into the system, a POSA could overcome these known problems in the prior art. Additionally, a POSA would understand an additional benefit of spatial binaural audio, or audio localization (in conjunction with head-tracking), is that it allows the



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participant to direct their attention (or focus) to a speaker by turning the head, and thus receive sound from the speaker evenly through both ears—i.e., naturalistically. This natural focusing often allows a person to hear the speaker better, including when other participants are talking. Therefore, a POSA developing a telephone communication system would have been motivated to combine references to achieve these known benefits and overcome these known problems in the prior art.

A POSA developing a communication system would also have been motivated to include sound filtering and processing techniques to, for example, account for changes in the position of the listener or of their head. For instance, it was well known to a POSA that for a stationary virtual sound source to keep its position in a virtual auditory environment when the listener moves, the selection of proper Head-Related Transfer Functions (HRTFs) and subsequent calculation of a distance from the person to the virtual sound source is required. Thus, for many dynamic applications of binaural technology, tracking a listener's position in space and possibly head orientation is crucial for a successful result. Therefore, a POSA would have been motivated to combine references that track and account for the user's position. Moreover, a POSA would have understood that with a known Interaural Time Difference (ITD) for the listener, it is possible to adapt the binaural audio data presented to the listener to individual characteristics of the listener and thereby improve auditory localization performance in binaural synthesis applications. These known techniques of processing audio increase user comprehension and immersion. Therefore, a POSA would have been motivated to combine references to achieve these known benefits and overcome these known problems in the prior art.

A POSA, developing a communication system would also have been motivated to include a controller or other input means to give the user more control over the virtual environment and allow the user to issue commands. A POSA, developing a communication system, would have,



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for example, known that success of systems is fueled by consumer demand and user enjoyment. In particular, a POSA would have been motivated to include command systems or controllers to increase system flexibility, usability, and enjoyment. For example, a POSA would have understood that when listening to audio, a user may want to manipulate the audio signal. For example, the user may wish to increase the loudness of the audio signals disturbed by background noise coming from the same spatial direction. As another example, the user may want to increase the loudness of audio signals that are most interesting to the user (for example, such as in a teleconference, the most critical speakers or the speakers that address issues of the most interest to the user), or that simply have too low of a sound volume. In an instance in which an event in the listening environment occurs suddenly and requires the user to pay attention (e.g., a person enters a room), the user may want to temporarily lower the sound volume of the audio signals located in a direction while leaving other audio objects intact, thus allowing the user to continue listening without interruption. For example, during a teleconference, the user may want to quickly re-position some audio signals for increased clarity. As another example, when a user listens to music, the user may wish to modify the characteristics of some audio objects to enhance the listening experience. Therefore, a POSA would have been motivated to combine references that include command systems or controllers because such systems may enable rich manipulation of an audio scene through efficient and easy-to-use methods with natural interaction; such as using a controller or input device allowing a user to issue commands to the system.

Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.A, with each other, or any of the references discussed in Sections IV.J.1-4, 8, 10, and 12 would have resulted in an arrangement of known elements. The resulting



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combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**2. The ’628 Patent**

A POSA developing, for example, a communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching displaying images in a virtual world as representations of conference participants. As discussed, it was known in the art that it is important to provide users with visual representations of sound sources so that the user may focus on specific audio and move in relation to audio sources.

A POSA also would have had a reasonable expectation of success in incorporating images into a communication system because there are a variety of ways to implement virtual images and to associate virtual images with binaural sound. The prior art discloses and teaches, for example, processing audio, such as a conference participant’s voice, with proper head related transfer functions to localize the participant’s voice to the participant’s image representation.

A POSA also would have had a reasonable expectation of success in incorporating interaction using a handheld portable electronic device because there are a variety of ways to implement a handheld portable electronic device for issuing commands or other instructions to the system. The prior art discloses and teaches, for example, at least inputting instructions into a graphical user interface on a handheld tablet computer, performing hand gestures that the system interprets, and/or moving an avatar in the virtual world.

As another example, a POSA developing a communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching adjusting attenuation and reverberation of sound emitting from sound sources where the sound is artificial. Because a participant can be exposed to multiple sound sources, it would have been



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obvious to incorporate the ability to modify attenuation and reverberation to differentiate said sound sources.

In addition, a POSA developing a communication system would have been motivated to include spatial binaural audio or audio localization. For example, it was well-known in the art that spatial audio can be useful whenever a listener is presented with multiple auditory streams. Spatial audio requires information about the positions of all events that need to be audible, including those that would benefit from increased immersion in a virtual environment. Indeed, to a POSA, it would have been well-understood that binaural recordings sound more realistic as they are recorded in a manner that more closely resembles the human acoustic system. And therefore, using binaural audio increases user immersion and realism.

Additionally, a POSA developing a communication system would have understood that many systems are limited to transmitting single-channel audio signals between users. Therefore, when conferences occur over typical communication systems, for example, the spatial reference is often lost through single-channel communication. It is often difficult to determine which participant is speaking when multiple participants sound similar or when there are many participants. However, by integrating spatial binaural audio or audio localization into the system, a POSA could overcome these known problems in the prior art. Additionally, a POSA would understand an additional benefit of spatial binaural audio, or audio localization (in conjunction with head-tracking), is that it allows the participant to direct their attention (or focus) to a speaker by turning the head, and thus receive sound from the speaker evenly through both ears—i.e., naturalistically. This natural focusing often allows a person to hear the speaker better, including when other participants are talking. Therefore, a POSA developing a communication system



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would have been motivated to combine references to achieve these known benefits and overcome these known problems in the prior art.

A POSA developing a communication system would also have been motivated to include sound filtering and processing techniques to, for example, account for changes in the position of the listener or of their head. For instance, it was well known to a POSA that for a stationary virtual sound source to keep its position in a virtual auditory environment when the listener moves, the selection of proper Head-Related Transfer Functions (HRTFs) and subsequent calculation of a distance from the person to the virtual sound source is required. Thus, for many dynamic applications of binaural technology, tracking a listener's position in space and possibly head orientation is crucial for a successful result. Therefore, a POSA would have been motivated to combine references that track and account for the user's position. Moreover, a POSA would have understood that with a known Interaural Time Difference (ITD) for the listener, it is possible to adapt the binaural audio data presented to the listener to individual characteristics of the listener and thereby improve auditory localization performance in binaural synthesis applications. These known techniques of processing audio increase user comprehension and immersion. Therefore, a POSA would have been motivated to combine references to achieve these known benefits and overcome these known problems in the prior art.

Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.B, with each other, or any of the references discussed in Sections IV.J.1, 2, 4, 6, 8, 10, and 12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.



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### 3. The ’090 Patent

A POSA developing, for example, a communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching adjusting the interaural time difference for sound sources. As discussed, it was known in the art that it is important to maintain the user’s ability to focus on specific sound sources, which can be achieved by adjusting the interaural time difference for audio emitting from said sound source. The known art also considers tracking the positions of the user’s ears, such as by using wireless signals or sensors, which enables systems to perform adjustments to the interaural time difference. Thus, a POSA would have had a reasonable expectation of success in incorporating interaural time difference adjustments.

As another example, a POSA developing a communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching maintain a sound source at a fixed location while a user moves his or her head or position because, as explained in the known prior art, it is important to enable the user to focus on and interact with a specific sound source even as the user navigates and interacts with his or her virtual environment. The prior art discloses or teaches adjusting binaural audio using, for example, proper head related transfer functions, interaural time difference, and/or reverberation, in tandem with head orientation tracking, to enable a user to move while the binaural audio localizes to the same fixed point in the virtual world.

A POSA also would have had a reasonable expectation of success in incorporating interaction using a handheld portable electronic device because there are a variety of ways to implement a handheld portable electronic device for issuing commands or instructions to the system. The prior art discloses and teaches, for example, at least inputting instructions into a



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graphical user interface on a handheld tablet computer, performing hand gestures that the system interprets, and/or moving an avatar in the virtual world.

As another example, a POSA developing a communication system where the user uses a wearable electronic device would have been motivated to look to references disclosing or teaching adjusting attenuation and reverberation of sound emitting from sound sources where the sound is artificial. Because a participant is exposed to multiple sound sources, it would have been obvious to incorporate the ability to modify attenuation and reverberation to differentiate said sound sources.

In addition, a POSA developing a communication system would have been motivated to include spatial binaural audio or audio localization. For example, it was well-known in the art that spatial audio can be useful whenever a listener is presented with multiple auditory streams. Spatial audio requires information about the positions of all events that need to be audible, including those that would benefit from increased immersion in a virtual environment. Indeed, to a POSA, it would have been well-understood that binaural recordings sound more realistic as they are recorded in a manner that more closely resembles the human acoustic system. And therefore, using binaural audio increases user immersion and realism.

Additionally, a POSA developing a communication system would have understood that many systems are limited to transmitting single-channel audio signals between users. Therefore, when conferences occur over typical communication systems, the spatial reference is often lost through single-channel communication. It is often difficult to determine which participant is speaking during a conference call when multiple participants sound similar or when there are many participants. However, by integrating spatial binaural audio or audio localization into the system, a POSA could overcome these known problems in the prior art. Additionally, a POSA would



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understand an additional benefit of spatial binaural audio, or audio localization (in conjunction with head-tracking), is that it allows the participant to direct their attention (or focus) to a speaker by turning the head, and thus receive sound from the speaker evenly through both ears—i.e., naturalistically. This natural focusing often allows a person to hear the speaker better, including when other participants are talking. Therefore, a POSA developing a telephone communication system would have been motivated to combine references to achieve these known benefits and overcome these known problems in the prior art.

A POSA developing a communication system would also have been motivated to include sound filtering and processing techniques to, for example, account for changes in the position of the listener or of their head. For instance, it was well known to a POSA that for a stationary virtual sound source to keep its position in a virtual auditory environment when the listener moves, the selection of proper Head-Related Transfer Functions (HRTFs) and subsequent calculation of a distance from the person to the virtual sound source is required. Thus, for many dynamic applications of binaural technology, tracking a listener's position in space and possibly head orientation is crucial for a successful result. Therefore, a POSA would have been motivated to combine references that track and account for the user's position. Moreover, a POSA would have understood that with a known Interaural Time Difference (ITD) for the listener, it is possible to adapt the binaural audio data presented to the listener to individual characteristics of the listener and thereby improve auditory localization performance in binaural synthesis applications. These known techniques of processing audio increase user comprehension and immersion. Therefore, a POSA would have been motivated to combine references to achieve these known benefits and overcome these known problems in the prior art.



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A POSA, developing a communication system would also have been motivated to include a controller or other input means to give the user more control over the virtual environment and allow the user to issue commands or instructions. A POSA developing a communication system would have known that success of systems is fueled by consumer demand and user enjoyment. In particular, a POSA would have been motivated to include command systems or controllers to increase system flexibility, usability, and enjoyment. For example, a POSA would have understood that when listening to audio, a user may want to manipulate the audio signal. For example, the user may wish to increase the loudness of the audio signals disturbed by background noise coming from the same spatial direction. As another example, the user may want to increase the loudness of audio signals that are most interesting to the user (for example, such as in a teleconference, the most critical speakers or the speakers that address issues of the most interest to the user), or that simply have too low of a sound volume. In an instance in which an event in the listening environment occurs suddenly and requires the user to pay attention (e.g., a person enters a room), the user may want to temporarily lower the sound volume of the audio signals located in a direction while leaving other audio objects intact, thus allowing the user to continue listening without interruption. For example, during a teleconference, the user may want to quickly re-position some audio signals for increased clarity. As another example, when a user listens to music, the user may wish to modify the characteristics of some audio objects to enhance the listening experience. Therefore, a POSA would have been motivated to combine references that include command systems or controllers because such systems may enable rich manipulation of an audio scene through efficient and easy-to-use methods with natural interaction; such as using a controller or input device allowing a user to issue commands or instructions to the system.



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Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.C, with each other, or any of the references discussed in Sections IV.J.1-4, 8, and 10-12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**4. The '184 Patent**

A POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching a guidance or safety system where the user is able to set boundaries. A POSA also would have been motivated to modify audio alerts, such that they would be made more relevant for users. In particular, changing audio volume and changing binaural sound to stereo sound were well-known options for audio indicators or alerts for crossing a boundary or leaving virtual objects in an area. As discussed in the known art, it is important to provide the user with reassurance of physical safety and protect the user from crashing into objects or walls in the physical environment, which would otherwise distract from the visual elements (either virtual, or augmented) presented on the wearable device with a display.

A POSA also would have had a reasonable expectation of success in incorporating binaural audio alerts, such a reduction in volume or altering binaural sound, in a guidance or safety system because reducing volume was a known way to indicate distance from an object or area, and altering binaural sound was a known way to indicate relevance. Using a reduction in volume or other alteration of processing of binaural sound had been implemented successfully in conjunction with a wearable device in the prior art. With respect to providing an alert that a user is leaving an area, audio alerts warning a user that they were leaving an image or an area had been implemented in



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the prior art. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art.

As another example, a POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching methods for generating and playing binaural audio. Binaural audio was well-known and long-studied. Because a wearable device with a display oftentimes includes speakers for the user also to receive audio input, it would have been obvious to incorporate an audio engine for generating binaural audio to provide the user with an extended reality experience that is not purely visual but aural as well.

Furthermore, the prior art discloses and teaches various configurations of a wearable device and the processors performing functionalities such as tracking the user or running an audio engine to generate binaural audio. For example, in certain contexts, the processing takes place at a computer or console that communicates via a wired or wireless connection to the wearable device. In other contexts, the processing takes place on a handheld device that communicates via a wired or wireless connection to the wearable device. In yet other contexts, the processing takes place on a processor located in the wearable device itself. All options considered, a POSA would have been motivated to incorporate as many functionalities as possible—while considering processing speed and any latency effects—into the processor located in the wearable device itself because doing so eliminates reliance on multiple computing devices, simplifies the system, and permits greater degrees of freedom for the user wearing the wearable device. A POSA would also have been motivated to efficiently process binaural audio, including use of a DSP for binaural audio processing or by prioritizing certain sounds and deprioritzing other sounds to save processing power.



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Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.D, with each other, or any of the references discussed in Sections IV.J.6-8 and 12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**5. The '179 Patent**

A POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching a guidance or safety system where the user is able to set boundaries. A POSA would have been motivated to modify audio alerts, such that they would be made more relevant for users. In particular, changing audio volume and changing binaural sound to stereo sound were well-known options for audio indicators or alerts for crossing a boundary or leaving virtual objects in an area. As discussed in the known art, it is important to provide the user with reassurance of physical safety and protect the user from crashing into objects or walls in the physical environment, which would otherwise distract from the visual elements (either virtual, or augmented) presented on the wearable device with a display.

A POSA also would have had a reasonable expectation of success in incorporating binaural audio alerts, such a reduction in volume or altering binaural sound, in a guidance or safety system because reducing volume was a known way to indicate distance from an object or area, and altering binaural sound was a known way to indicate relevance. Using a reduction in volume or other alteration of processing of binaural sound had been implemented successfully in conjunction with a wearable device in the prior art. With respect to providing an alert that a user is leaving an area, audio alerts warning a user that they were leaving an image or an area had been implemented in



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the prior art. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art.

As another example, a POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching methods for generating and playing binaural audio. Binaural audio was well-known and long-studied. Because a wearable device with a display oftentimes includes speakers for the user also to receive audio input, it would have been obvious to incorporate an audio engine for generating binaural audio to provide the user with an extended reality experience that is not purely visual but aural as well.

Furthermore, the prior art discloses and teaches various configurations of a wearable device and the processors performing functionalities such as tracking the user or running an audio engine to generate binaural audio. For example, in certain contexts, the processing takes place at a computer or console that communicates via a wired or wireless connection to the wearable device. In other contexts, the processing takes place on a handheld device that communicates via a wired or wireless connection to the wearable device. In yet other contexts, the processing takes place on a processor located in the wearable device itself. All options considered, a POSA would have been motivated to incorporate as many functionalities as possible—while considering processing speed and any latency effects—into the processor located in the wearable device itself because doing so eliminates reliance on multiple computing devices, simplifies the system, and permits greater degrees of freedom for the user wearing the wearable device. A POSA would also have been motivated to efficiently process binaural audio, including use of a DSP for binaural audio processing or by prioritizing certain sounds and deprioritzing other sounds to save processing power.



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Additionally, a POSA also would have understood the combination of any of the references discussed in Section I.A.9, with each other, or any of the references discussed in Sections IV.J.6-8, and 12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**6. The '737 Patent**

A POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching a guidance or safety system where the user is able to set boundaries. As discussed, it was known in the art that it is important to provide the user with reassurance of physical safety and protect the user from crashing into objects or walls in the physical environment, which would otherwise distract from the visual elements (either virtual, or augmented) presented on the wearable device with a display. It was also known in the art the benefits and advantages of using boundaries to demarcate zones relating to certain sound sources for the user to navigate in a virtual environment.

A POSA also would have had a reasonable expectation of success in incorporating a guidance or safety system because there are a variety of ways to designate a boundary as well as track the user's location relative to that boundary. With respect to designating a boundary, the prior art discloses and teaches at least gaze-tracking, tracking movement with external cameras or sensors, and moving a trackable device (e.g., wearable device or handheld device) to various locations in the physical environment to designate a boundary. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art. With respect to tracking the user's location relative to that boundary, the prior art discloses and teaches at least tracking via positioning systems, positional or orientation sensors built into the wearable device



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and/or handheld device, pairing depth cameras with the wearable device, image tracking with cameras or lights, and utilizing sensors and markets placed throughout the physical environment. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art. Additionally, methods and systems of devices (e.g., wearable device or handheld device) communicating with and tracking each other were well known in the art.

As another example, a POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching methods for generating and playing binaural audio. Binaural audio was well-known and long-studied. Because a wearable device with a display oftentimes includes speakers for the user to receive audio input, it would have been obvious to incorporate an audio engine for generating binaural audio to provide the user with an extended reality experience that is not purely visual but aural as well. Additionally, a POSA would have known that an application of binaural audio in the context of an extended reality system is to associate the audio with a virtual image or character, such as in a game.

Furthermore, the prior art discloses and teaches various configurations of a wearable device and its processors performing functionalities such as tracking the user or running an audio engine to generate binaural audio. For example, in certain contexts, the processing takes place at a computer or console that communicates via a wired or wireless connection to the wearable device. In other contexts, the processing takes place on a handheld device that communicates via a wired or wireless connection to the wearable device. In yet other contexts, the processing takes place on a processor located in the wearable device itself. All options considered, a POSA would have been motivated to incorporate as many functionalities as possible—while considering processing speed and any latency effects—into the processor located in the wearable device itself because doing so



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eliminates reliance on multiple computing devices, simplifies the system, and permits greater degrees of freedom for the user wearing the wearable device.

Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.F, with each other, or any of the references discussed in Sections IV.J.1-6 and 12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**7. The '509 Patent**

A POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching a guidance or safety system where the user is able to set boundaries. As discussed, it was known in the art that it is important to provide the user with reassurance of physical safety and protect the user from crashing into objects or walls in the physical environment, which would otherwise distract from the visual elements (either virtual, or augmented) presented on the wearable device with a display. It was also known in the art the benefits and advantages of using boundaries to demarcate zones relating to certain sound sources for the user to navigate in a virtual environment.

A POSA also would have had a reasonable expectation of success in incorporating a guidance or safety system because there are a variety of ways to designate a boundary as well as track the user's location relative to that boundary. With respect to designating a boundary, the prior art discloses and teaches at least gaze-tracking, tracking movement with external cameras or sensors, and moving a trackable device (e.g., wearable device or handheld device) to various locations in the physical environment to designate a boundary. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art. With respect to



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tracking the user's location relative to that boundary, the prior art discloses and teaches at least tracking via positioning systems, positional or orientation sensors built into the wearable device and/or handheld device, pairing depth cameras with the wearable device, image tracking with cameras or lights, and utilizing sensors and markets placed throughout the physical environment. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art. Additionally, methods and systems of devices (e.g., wearable device or handheld device) communicating with and tracking each other were well known in the art.

As another example, a POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching methods for generating and playing binaural audio. Binaural audio was well-known and long-studied. Because a wearable device with a display oftentimes includes speakers for the user to receive audio input, it would have been obvious to incorporate an audio engine for generating binaural audio to provide the user with an extended reality experience that is not purely visual but aural as well. Additionally, a POSA would have known that an application of binaural audio in the context of an extended reality system is to associate the audio with a virtual image or character, such as in a game.

Furthermore, the prior art discloses and teaches various configurations of a wearable device and its processors performing functionalities such as tracking the user or running an audio engine to generate binaural audio. For example, in certain contexts, the processing takes place at a computer or console that communicates via a wired or wireless connection to the wearable device. In other contexts, the processing takes place on a handheld device that communicates via a wired or wireless connection to the wearable device. In yet other contexts, the processing takes place on a processor located in the wearable device itself. All options considered, a POSA would have been



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motivated to incorporate as many functionalities as possible—while considering processing speed and any latency effects—into the processor located in the wearable device itself because doing so eliminates reliance on multiple computing devices, simplifies the system, and permits greater degrees of freedom for the user wearing the wearable device.

Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.G, with each other, or any of the references discussed in Sections IV.J.1-6 and 12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**8. The '316 Patent**

A POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching a guidance or safety system where the user is able to set boundaries. As discussed, it was known in the art that it is important to provide the user with reassurance of physical safety and protect the user from crashing into objects or walls in the physical environment, which would otherwise distract from the visual elements (either virtual, or augmented) presented on the wearable device with a display. It was also known in the art the benefits and advantages of using boundaries to demarcate zones relating to certain sound sources for the user to navigate in a virtual environment.

A POSA also would have had a reasonable expectation of success in incorporating a guidance or safety system because there are a variety of ways to designate a boundary as well as track the user's location relative to that boundary. With respect to designating a boundary, the prior art discloses and teaches at least gaze-tracking, tracking movement with external cameras or sensors, and moving a trackable device (e.g., wearable device or handheld device) to various



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locations in the physical environment to designate a boundary. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art. With respect to tracking the user's location relative to that boundary, the prior art discloses and teaches at least tracking via positioning systems, positional or orientation sensors built into the wearable device and/or handheld device, pairing depth cameras with the wearable device, image tracking with cameras or lights, and utilizing sensors and markets placed throughout the physical environment. Each of these options has been implemented successfully in conjunction with a wearable device in the prior art. Additionally, methods and systems of devices (e.g., wearable device or handheld device) communicating with and tracking each other were well known in the art.

As another example, a POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching methods for generating and playing binaural audio. Binaural audio was well-known and long-studied. Because a wearable device with a display oftentimes includes speakers for the user to receive audio input, it would have been obvious to incorporate an audio engine for generating binaural audio to provide the user with an extended reality experience that is not purely visual but aural as well. Additionally, a POSA would have known that an application of binaural audio in the context of an extended reality system is to associate the audio with a virtual image or character, such as in a game.

Furthermore, the prior art discloses and teaches various configurations of a wearable device and its processors performing functionalities such as tracking the user or running an audio engine to generate binaural audio. For example, in certain contexts, the processing takes place at a computer or console that communicates via a wired or wireless connection to the wearable device. In other contexts, the processing takes place on a handheld device that communicates via a wired



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or wireless connection to the wearable device. In yet other contexts, the processing takes place on a processor located in the wearable device itself. All options considered, a POSA would have been motivated to incorporate as many functionalities as possible—while considering processing speed and any latency effects—into the processor located in the wearable device itself because doing so eliminates reliance on multiple computing devices, simplifies the system, and permits greater degrees of freedom for the user wearing the wearable device.

Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.H, with each other, or any of the references discussed in Sections IV.J.1-7 and 12 would have resulted in an arrangement of known elements. The resulting combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

**9. The '836 Patent**

A POSA developing a virtual or augmented reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching a binaural sound system where the user is able to perceive sound as originating from a localized position. As discussed in the known art, it is important to provide the user with localized sound which without, the user would otherwise be distracted from the visual elements (either virtual, or augmented) presented on the wearable device with a display and would be unable to be immersed in the virtual or augmented reality.

A POSA also would have had a reasonable expectation of success in incorporating a wearable device with a display capable of rendering an image in relation to a sound source using known methods and instrumentalities such as, processors capable of processing binaural audio through the use of head related transfer functions. These instrumentalities have been implemented successfully in conjunction with a wearable device in the prior art.



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A POSA developing an extended reality system where the user uses a wearable device with a display (e.g., head-mounted display) would have been motivated to look to references disclosing or teaching methods for generating and playing binaural audio such that the sound and image are rendered in relation to one another. Processing binaural audio was well-known and long-studied. Because a wearable device with a display oftentimes includes speakers for the user also to receive audio input, it would have been obvious to incorporate an audio engine for generating binaural audio to provide the user with an extended reality experience that is not purely visual but aural as well.

Furthermore, the prior art discloses and teaches various configurations of a wearable device and the processors performing functionalities such as tracking the user or running an audio engine to generate binaural audio. For example, in certain contexts, the processing takes place at a computer or console that communicates via a wired or wireless connection to the wearable device. In other contexts, the processing takes place on a handheld device that communicates via a wired or wireless connection to the wearable device. In yet other contexts, the processing takes place on a processor located in the wearable device itself.

All options considered, a POSA would have been motivated to incorporate as many functionalities as possible—while considering processing speed and any latency effects—into the processor located in the wearable device itself because doing so eliminates reliance on multiple computing devices, simplifies the system, and permits greater degrees of freedom for the user wearing the wearable device.

Additionally, a POSA also would have understood the combination of any of the references discussed in Section IV.I, with each other, or any of the references discussed in Sections IV.J.1, 2, 6, 8-9, and 12 would have resulted in an arrangement of known elements. The resulting



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combinations of references are comprised of nothing more than known references and features, operating as they were known to, and yielding predictable results.

## V. SECONDARY CONSIDERATIONS

Subject to Defendants' general statements and reservation of rights, Defendants contend that an analysis of secondary considerations further supports the view that each of the Asserted Claims is obvious. Secondary considerations that courts evaluate as objective indicia of obviousness or non-obviousness of an alleged invention include (1) commercial success of the claimed subject matter; (2) long felt but unresolved needs; (3) failure of others; (4) teaching away from the claimed subject matter by the prior art; (5) copying or acclamation by others; and (6) skepticism of experts. *See, e.g.*, *Ruiz v. A.B. Chance Co.*, 357 F.3d 1270, 1274 (Fed. Cir. 2004); *Ecolochem, Inc. v. Southern Cal. Edison Co.*, 227 F.3d 1361, 1379 (Fed. Cir. 2000). Plaintiff has not identified any secondary considerations yet, and Defendants contend that none indicates nonobviousness. To the extent Plaintiff identifies any purported secondary considerations, Defendants reserve all rights to respond at the appropriate time, including by amending, supplementing, or otherwise modifying these contentions.

## VI. INCORRECT INVENTORSHIP

The Asserted Claims of the Asserted Patents are invalid because it appears the applicants did not invent the Asserted Claims' alleged inventions.

All nine of the Asserted Patents list Philip Scott Lyren and Glen A. Norris as their purported inventors. Mr. Norris seems to be the director of MicroKarma, an apparent micro-crowdfunding company, and is listed as an inventor on over 190 patents and applications, for at least 15 patent families. Mr. Norris seems to have received a bachelor's degree in computer science from Case Western University in 1988 and to have held managerial and consulting positions in various companies. Mr. Lyren is an attorney barred in Texas. A 2014 ArsTechnica article identifies him



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as a "lawyer-inventor" and the manager—and possible owner—of Red Pine Point LLC. *See* https://arstechnica.com/tech-policy/2014/01/meet-the-inventor-of-the-week-patent-troll-owns-pre-release-digital-movies/. Mr. Lyren appears to be listed as an inventor on over 350 patents and patent applications, for over 45 patent families, which cover a wide variety of technologies, including firearm systems, hip implants, and home appliances, to name a few. Mr. Lyren's background, however, seems to be primarily directed to patent prosecution, not any particular technological field. It appears that Mr. Lyren is currently Director and IP Counsel at an entity named C Matter LLC, a Nevada Domestic Limited Liability Company (though C Matter's filing status, file number E0464882014-4, is listed as Permanently Revoked as of October 1, 2016. *See* https://www.bizapedia.com/nv/c-matter-llc.html). C Matter's company information identifies both Messrs. Norris and Lyren as managers.

Based on at least the foregoing, it appears that Messrs. Norris and Lyren are in the business of serially obtaining patents and asserting them, including against products and for alleged inventions that they did not invent. For example, the '509 Patent's application—the '936 Application—was filed as a continuation on July 25, 2020. In contrast to all other earlier, related applications, the '936 Application purports to be directed to a "wearable electronic device" that "displays a 3D zone from where binaural sound emanates," where the zone is "divide[d from] an area around a user" using "[a] portable electronic device." '509 Patent at Title, Abstract. Earlier related applications, such as the application filed on October 17, 2018 that matured into U.S. Patent No. 10,440,489, in contrast, were directed to "generat[ing] a sound localization point" based on "a location of a handheld portable electronic device," and using that sound localization point during a telephone call. *See, e.g.*, U.S. Patent No. 10,440,489 at Title, Abstract. Notably, between October 17, 2018 and July 25, 2020, Meta made a number of its Oculus systems that use the Oculus



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Guardian System available to the public, including Rift S (announced March 20, 2019, available May 21, 2019); Oculus Quest 1 (announced September 26, 2018, available May 21, 2019); and Oculus Quest 2 (announced September 16, 2020, available October 13, 2020). And as discussed in Section VII.G below, there is inadequate written description support in the '509 Patent's specification for that patent's Asserted Claims. For at least these reasons, Messrs. Norris and Lyren are not proper inventors of the alleged inventions recited in the Asserted Claims of the '509 Patent, which appear to have been derived from, and based on, publicly available Meta products and information.

For the same reasons Messrs. Norris and Lyren are not proper inventors of the alleged inventions recited in the Asserted Claims of the '509 Patent, they are not proper inventors of the alleged inventions recited in the Asserted Claims of the '737 and '316 Patents, which similarly recite purported inventions that are, among other things, unsupported by the patents' specifications and seem derived from, and based on, publicly available Meta products and information, not any actual inventions created by Messrs. Norris and Lyren. *See* Sections VII.F, VII.H.

Discovery is ongoing and Defendants reserve all rights to supplement these invalidity contentions to further address the Asserted Claims' inventorship.

## VII. INVALIDITY UNDER 35 U.S.C. § 112

The Asserted Claims of the Asserted Patents fail to satisfy 35 U.S.C. § 112. Section 112 provides that a patent specification "shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make, and use the same[.]" This language creates two closely related, yet separate written description and enablement requirements: (i) a written description of the invention and (ii) a written description of the manner and process of making and using the invention. *Ariad Pharms.,*



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*Inc. v. Eli Lilly Co.*, 598 F.3d 1336, 1344 (Fed. Cir. 2010) (*en banc*).

The test for written description requires "an objective inquiry into the four corners of the specification from the person of ordinary skill in the art." *Id.* at 1351. "Based on that inquiry, the specification must describe an invention understandable to that skilled artisan to show that the inventor actually invented the invention claimed." *Id.* A patent is invalid for inadequate written description unless "the disclosure of the application relied upon reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date." *Id.*

The enablement requirement requires that the disclosures in a specification describe "the manner and process of making and using [the invention], in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the [invention]." 35 U.S.C. § 112. To satisfy this requirement, the specification "must teach those skilled in the art how to make and use the full scope of the claimed invention without 'undue experimentation.'" *ALZA Corp. v. Andrx Pharms., LLC*, 603 F.3d 935, 940 (Fed. Cir. 2010).

Section 112 also requires that a claim be definite. To satisfy this requirement, a claim must particularly point out and distinctly claim the subject matter which the inventors regarded as their alleged invention such that one skilled in the relevant art would be reasonably apprised of the bounds of the Asserted Claims when read in light of the specification. *Nautilus, Inc. v. Biosig, Inc.*, 134 S.Ct. 2120, 2129 (2014) ("require[s] that a patent's claims, viewed in light of the specification and prosecution history, inform those skilled in the art about the scope of the invention with reasonable certainty").

Additionally, claims governed by 35 U.S.C. § 112(f) are indefinite if "the claim term fails



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to recite sufficiently definite structure or else recites function without reciting sufficient structure for performing that function." *Williamson v. Citrix Online, LLC*, 792 F.3d 1339 (en banc). Claims need not contain the word "means" to implicate § 112(f). *Id.* For computer-implemented functions, the structure corresponding to a § 112(f) limitation "must include the algorithm needed to transform the general purpose computer or microprocessor disclosed in the specification" to a "special purpose computer" programmed to perform the claimed function. *See Aristocrat Techs. Australia PTY Ltd. v. Int'l Game Tech.*, 521 F.3d 1328, 1333 (Fed. Cir. 2008).

Further, any claim that mixes statutory classes of invention, e.g., by reciting both an apparatus and method steps of using the apparatus, is indefinite under Section 112—the reason being that it is unclear when infringement occurs.

The identifications of limitations failing to satisfy § 112 set out below are based on Defendants' current knowledge. Further investigation, discovery, and disclosures may uncover additional grounds for invalidity under § 112. For example, Plaintiff may attempt to remedy its currently deficient infringement contentions and in doing so reveal (or confirm) that it attributes unjustifiable, unsupported, and uncertain scope to the Asserted Claims. As another example, should Plaintiff contend that the preambles of the Asserted Claims are not limiting, then Plaintiff's interpretation of certain preambles as non-limiting will run afoul of the prescription against mixing statutory classes of invention, which will render any such Asserted Claims invalid as indefinite.

Defendants reserve the right to supplement and/or amend these disclosures, including to advance additional § 112 defenses, as appropriate.

**A. The '196 Patent**

Based on Defendants' present understanding and investigation of the Asserted Claims of the '196 Patent, including Defendants' review of Plaintiff's apparent (mis)interpretations of those



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claims, the Asserted Claims of the '196 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- "receiving, from the user and at the HPED, a command to move the SLP of the voice of the computer program" (claims 1, 4);
- "moving, based on the command and during the voice exchange between the computer program and the user, the SLP of the voice of the computer program" (claim 1);
- "away from and proximate to the user" / "away from and proximate to the person" (claims 1, 4, 15, 19);
- "adjusting a sound of the voice of the computer program that the user hears through the electronic earphone" (claim 4);
- "move the SLP of the voice of the computer program in response to the command from the first location in empty space to the second location in empty space" (claims 15, 19);
- "a processor that executes the instructions to receive a command from the person to move the SLP of the voice of the computer program from the first location in empty space to a second location in empty space that is proximate to the first location and away from and proximate to the person, move the SLP of the voice of the computer program in response to the command from the first location in empty space to the second location in empty space, and provide binaural sound to the person through the wearable electronic device during the voice exchange between the computer program and the person such that an origin of the voice of the computer program occurs at the SLP at the second location in empty space that is proximate to the first location and away from and proximate to the person" (claims 15, 19);
- "The electronic system of claim 15, wherein the processor further executes the instructions to change attenuation and reverberation of the binaural sound in order to add artificial audial cues of virtual objects near the person" (claim 19); and
- "wherein the virtual objects do not actually exist near the person but are perceived to exist by the person from the artificial audial cues" (claim 19).

**B. The '628 Patent**

Based on Defendants' present understanding and investigation of the Asserted Claims of the '628 Patent, including Defendants' review of Plaintiff's apparent (mis)interpretation of those claims, the Asserted Claims of the '628 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- "processing, during the telephone call and with a processor, a voice of the calling party with head related transfer functions (HRTFs) so the voice of the calling party localizes to the called party as binaural sound at a sound localization point (SLP) that is one



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meter to two meteres away from the called party" / "processing, during the telephone call, a voice of the calling party with head related transfer functions (HRTFs) so the voice of the calling party localizes to the called party as binaural sound at the image of the calling party that appears at least one meter away from the head of the called party" (claims 9, 12, 16);

- "changing, during the telephone call and in response to the head movements of the called party, the HRTFs processing the voice of the calling party so the voice of the calling party continues to localize to the SLP that is seen by the called party as being the image that represents the calling that is one meter to two meters away from the called party while the head of the called party moves with respect to the image that represents the calling party" / "changing, during the telephone call and in response to the head movements of the called party, the HRTFs processing the voice of the calling party so the voice of the calling party continues to localize to the image of the calling party that appears at least one meter away from the head of the called party as the head of the called party moves and changes head orientations" (claims 9, 12, 16);
- "displaying, during the telephone call and to the called party with a wearable electronic device worn on a head of the called party, an image that represents the calling party that is seen by the called party as being at the SLP that is one meter to two meters away from the called party" (claims 9, 12);
- "displaying, during the telephone call and to the called party with the wearable electronic device worn on the head of the called party, the image that represents the calling party as a virtual image of the calling party" / "displaying, during the telephone call and to the called party with the wearable electronic device worn on the head of the called party, an image of the calling party that appears to the called party as being at least one meter away from a head of the called party" (claims 12, 16); and
- "[a] non-transitory computer readable storage medium storing instructions that one or more electronic devices in an electronic system execute as a method during a telephone call between a calling party and a called party, the method comprising:" (claim 16).

### C. The '090 Patent

Based on Defendants' present understanding and investigation of the Asserted Claims of the '090 Patent, including Defendants' review of Plaintiff's apparent (mis)interpretation of those claims, the Asserted Claims of the '090 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- "commence an electronic call between a first individual wearing an electronic earphone and a second individual that are remote from each other" (claims 8, 14);
- "designate, for the first individual, a sound localization point that simulates a location in empty space from where an origin of a voice of the second individual occurs" (claims 8, 14);



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- "in empty space that is away from and proximate to the first individual" (claims 8, 14);
- "away from and proximate to the first individual" / "away from and proximate to the first person" (claims 8, 14, 15);
- "[a] non-transitory computer readable storage medium storing instructions that cause a computer system to execute a method, comprising" (claims 8, 14)
- "commence an electronic call between a first individual wearing an electronic earphone and a second individual that are remote from each other" (claims 8, 14); and
- "a processor that executes the instructions to adjust the binaural voice of the second person during the electronic phone call in order to position a sound localization point of the binaural voice to a location that is away from and proximate to the first person" (claim 15).

**D. The '184 Patent**

Based on Defendants' present understanding and investigation of the Asserted Claim of the '184 Patent, including Defendants' review of Plaintiff's apparent (mis)interpretation of that claim, the Asserted Claim of the '184 Patent fails to satisfy the requirements of § 112 with respect to at least the following terms:

- "processing, by a digital signal processor (DSP), sound with the HRTFs to generate binaural sound that externally localizes to the user at the virtual image in the environment" (claim 14);
- "alerting the user that the user is leaving the virtual image in the environment" (claim 14); and
- "alerting the user that the user is leaving the virtual image in the environment by altering processing of the binaural sound by the DSP and reducing a volume of the binaural sound that localizes to the user at the virtual image" (claim 14).

**E. The '179 Patent**

Based on Defendants' present understanding and investigation of the Asserted Claim of the '179 Patent, including Defendants' review of Plaintiff's apparent (mis)interpretation of that claim, the Asserted Claim of the '179 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- "processing, by a digital signal processor (DSP), sound with the HRTFs to generate binaural sound that externally localizes in empty space from the virtual image in the environment" (claim 14);



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- "determining, with the WED, when the user is leaving the environment" (claim 14); and
- "alerting the user that the user is leaving the environment by reducing a volume of the binaural sound that localizes from the virtual image and that is being provided to the user" (claim 14).

**F. The '737 Patent**

Based on Defendants' present understanding and investigation of the Asserted Claims of the '737 Patent, including Defendants' review of Plaintiff's apparent (mis)interpretation of those claims, the Asserted Claims of the '737 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- "tracking, with a wearable electronic device (WED) worn on a head of the user, movement of a handheld portable movement of a handheld portable electronic device (HPED) held in a hand of the user" / "tracking, the WED worn on the head of the user, the HPED such that the HPED provides a location to the WED of the SLP" (claim 1);
- "processing, by a processor, sound with head-related transfer functions (HRTFs) to generate the binaural sound that externally localizes to the user at the location of the SLP in empty space in the zone above the physical floor" (claim 1);
- "a wearable electronic device (WED) that is worn on a head of the user, tracks movement of the PED to determine the boundary of the 3D zone that extends from the physical floor and around the user, includes a processor that processes sound with head-related transfer functions (HRTFs) so sound externally localizes as binaural sound to the user at the SLP in empty space inside the 3D zone defined by movement of the PED and displays a virtual image at the SLP in empty space inside the 3D zone, and displays a 3D virtual image that shows the boundary of the 3D zone that extends from the physical floor and around the user" (claims 14, 15, 16);
- "such that the movement of the HPED defines a size and a shape of a three-dimensional (3D) zone" (claim 1) / "wherein the 3D zone has a customized size and shape defined by movement of the PED while held in the hand of the user" (claim 15);
- "a portable electronic device (PED) that moves to define a boundary of a three-dimensional (3D) zone extending from a physical floor" (claims 14, 15, 16);
- "a wearable electronic device (WED) that is worn on a head of the user, tracks movement of the PED to determine the boundary of the 3D zone" (claims 14, 15, 16); and
- "displays a 3D virtual image that shows the boundary of the 3D zone" (claim 14, 15) / "the WED automatically displays the 3D virtual image that shows the boundary of the 3D zone to alert the user that the PED is at the boundary of the 3D zone" (claim 16).



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### G. The ’509 Patent

Based on Defendants’ present understanding and investigation of the Asserted Claims of the ’509 Patent, including Defendants’ review of Plaintiff’s apparent (mis)interpretation of those claims, the Asserted Claims of the ’509 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- “[a] non-transitory computer readable storage medium storing instructions that one or more electronic devices execute as a method” (claims 9, 10);
- “dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a zone” (claims 9, 10);
- “determining, with a wearable electronic device (WED) worn on a head of the user, when the user is located inside the zone” (claims 9, 10);
- “determining, with the WED worn on the head of the user, when the user is leaving the zone” (claims 9, 10);
- “displaying, with the WED worn on the head of the user, a three dimensional (3D) virtual image of the zone in response to the WED determining that the user is leaving the zone” (claims 9, 10);
- “determining, with the WED, when the PED is pointed at one of the SLPs while the user is located in the zone” (claim 10);
- “playing the binaural sound that originates from the one of the SLPs in the zone in response to the WED determining that the PED is pointed at the one of the SLPs” (claim 10);
- “a portable electronic device (PED) held in a hand of a user that divides an area around the user into a three-dimensional (3D) zone that includes sound localization points (SLPs) in empty space from where binaural sound originates to the user” (claim 17);
- “one or more sensors that sense when the PED leaves the zone” (claim 17);
- “a display that displays a 3D virtual image of the zone in response to sensing that the PED leaves the zone, wherein the display displays the 3D virtual image of the zone to warn the user that the user is leaving the zone” (claim 17);
- “a wearable electronic device (WED) that is worn on a head of the user, wirelessly communicates with the PED, includes speakers that play the binaural sound to the user that emanates from the SLPs in empty space” (claim 17); and
- “wherein the display displays the 3D virtual image of the zone to warn the user that the user is leaving the zone” (claim 17).



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## H. The ’316 Patent

Based on Defendants’ present understanding and investigation of the Asserted Claims of the ’316 Patent, including Defendants’ review of Plaintiff’s apparent (mis)interpretation of those claims, the Asserted Claims of the ’316 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- “dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a three-dimensional (3D) zone that extends around the user” (claims 9, 10, 14);
- “determining, with a wearable electronic device (WED) worn on the head of the user, when the user is leaving the zone” (claims 9, 10, 14);
- “warning the user that the user is leaving the zone” (claims 9, 10, 14);
- “by displaying, with the WED worn on the head of the user, a 3D virtual reality (VR) image of the zone in response to the WED determining that the user is leaving the zone” (claims 9, 10);
- “determining, with the WED, when the PED is pointed at one of the SLPs while the user is located in the zone” (claim 10);
- “playing the binaural sound that originates from the one of the SLPs in the zone in response to the WED determining that the PED is pointed at the one of the SLPs” (claim 10); and
- “playing, with the WED worn on the head of the user, an audio warning indicating the user should move back into the zone in response to the WED determining that the user is leaving the zone” (claim 14).

## I. The ’836 Patent

Based on Defendants’ present understanding and investigation of the Asserted Claims of the ’836 Patent, including Defendants’ review of Plaintiff’s apparent (mis)interpretation of those claims, the Asserted Claims of the ’836 Patent fail to satisfy the requirements of § 112 with respect to at least the following terms:

- “one or more processors that process sound for the image to generate binaural sound that has a sound localization point (SLP) with a coordinate location that occurs at a far-field distance located behind the image and along a line-of-sight from the user to the image while the display displays the image to the user at the near-field distance, wherein the one or more processors include a digital signal processor (DSP) that processes the sound for the image with far-field head-related transfer functions



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(HRTFs) while electronic device is located at the near-field distance from the head of the user (claims 8, 10).

## VIII. INVALIDITY UNDER 35 U.S.C. § 101

Defendants provide below their invalidity contentions that the Asserted Claims of the Asserted Patents are invalid under § 101. These contentions are based on Defendants' current knowledge, investigation, and understanding of the scope of Plaintiff's allegations and apparent interpretations of the Asserted Claims. Consequently, Defendants reserve the right to supplement, amend, or otherwise modify these disclosures, including to add additional § 101 grounds as appropriate, e.g., in view of any attempt by Plaintiff to remedy the deficiencies in its infringement contentions, Plaintiff's provision of its claim construction positions, and/or Plaintiff's responses to Defendants' invalidity contentions or other discovery requests. Defendants similarly reserve the right to supplement, amend, or otherwise modify these contentions in view of other Court or case proceedings, e.g., after a *Markman* order is issued.

### A. The '196 Patent

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the '196 Patent are patent ineligible under § 101 because each Asserted Claim (i) is directed to the abstract idea of controlling the location from which a listener perceives a sound, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '196 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.A, III.J, IV.A, and IV.J (above).

### B. The '628 Patent

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the '628 Patent are patent ineligible under § 101 because each Asserted Claim



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(i) is directed to the abstract idea of controlling the location from which a listener perceives a sound, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '628 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.B, III.J, IV.B, and IV.J (above).

**C. The '090 Patent**

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the '090 Patent are patent ineligible under § 101 because each Asserted Claim (i) is directed to the abstract idea of controlling the location from which a listener perceives a sound, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '090 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections IV.C, III.J, IV.C, and IV.J (above).

**D. The '184 Patent**

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claim of the '184 Patent is patent ineligible under § 101 because it (i) is directed to the abstract idea of controlling sound in an environment to alert a person that he or she is leaving that environment, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '184 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.D, III.J, IV.D, and IV.J (above).

**E. The '179 Patent**

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claim of the '179 Patent is patent ineligible under § 101 because it (i) is directed to the



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abstract idea of controlling sound in an environment to alert a person that he or she is leaving that environment, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '179 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.E, III.J, IV.E, and IV.J (above).

**F. The '737 Patent**

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the '737 Patent are patent ineligible under § 101 because each Asserted Claim (i) is directed to the abstract idea of controlling sound and visuals in an environment, including to provide alerts, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '737 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.F, III.J, IV.F, and IV.J (above).

**G. The '509 Patent**

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the '509 Patent are patent ineligible under § 101 because each Asserted Claim (i) is directed to the abstract idea of controlling sound and visuals in an environment, including to provide alerts, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the '509 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.G, III.J, IV.G, and IV.J (above).

**H. The '316 Patent**

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the '316 Patent are patent ineligible under § 101 because each Asserted Claim



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(i) is directed to the abstract idea of controlling sound and visuals in an environment, including to provide warnings, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the ’316 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.H, III.J, IV.H, and IV.J (above).

### I. The ’836 Patent

Subject to the above statements and reservation of rights, Defendants contend that the Asserted Claims of the ’836 Patent are patent ineligible under § 101 because each Asserted Claim (i) is directed to the abstract idea of controlling the location from which a listener perceives a sound, and (ii) recites only well-understood, routine, and conventional components or activities, as evidenced by, for example, statements in the ’836 Patent itself as well as the prior art references and systems discussed elsewhere in these invalidity contentions. *See, e.g.*, Sections III.I, III.J, IV.I, and IV.J (above).



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Dated: February 14, 2023

Respectfully submitted,

*/s/ Jeffrey G. Homrig*

Jeffrey G. Homrig (*pro hac vice*)
Douglas E. Lumish (*pro hac vice*)
Saishruti Mutneja (*pro hac vice*)
LATHAM AND WATKINS LLP
140 Scott Drive
Menlo Park, CA 94025
Tel: (650) 328-4600 / Fax: (650) 463-2600
doug.lumish@lw.com
jeff.homrig@lw.com
saishruti.mutneja@lw.com

Giri Pathmanaban (SBN: 24074865)
LATHAM AND WATKINS LLP
301 Congress Avenue, Suite 900
Austin, TX 78701
Tel: (737) 910-7345 / Fax: (650) 463-2600
giri.pathmanaban@lw.com

Christopher W. Henry (*pro hac vice*)
Kimberly Q. Li (*pro hac vice*)
LATHAM & WATKINS, LLP
200 Clarendon Street
Boston, MA 02116
Tel: (617) 948-6000 / Fax: (617) 948-6001
christopher.henry@lw.com
kimberly.li@lw.com

Gabrielle A. LaHatte (*pro hac vice*)
LATHAM & WATKINS LLP
505 Montgomery Street, Suite 2000
San Francisco, CA 94111
Tel: (415) 391-0600 / Fax: (415) 395-8095
gabrielle.lahatte@lw.com

Ethan L. Plail (*pro hac vice*)
LATHAM & WATKINS, LLP
555 Eleventh Street, NW, Suite 1000
Washington, D.C. 20004
Tel: (202) 637-2200 / Fax: (202) 637-2201
ethan.plail@lw.com

Paige Arnette Amstutz (SBN: 00796136)
SCOTT, DOUGLASS & MCCONNICO, LLP



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303 Colorado Street, Suite 2400
Austin, TX 78701
Tel: (512) 495-6300 / Fax: (512) 495-6399
pamstutz@scottdoug.com

*Attorneys for Defendants Meta Platforms, Inc., Meta Platforms Technologies, LLC, and Twisted Pixel Games, LLC*



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**CERTIFICATE OF SERVICE**

The undersigned hereby certifies that all counsel of record, who are deemed to have consented to electronic service, are being served a copy of this document via electronic mail on this 14th day of February, 2023.

*/s/ Jeffrey G. Homrig*

Jeffrey G. Homrig (*pro hac vice*)
LATHAM AND WATKINS LLP
140 Scott Drive
Menlo Park, CA 94025
Tel: (650) 328-4600 / Fax: (650) 463-2600
jeff.homrig@lw.com

*Attorney for Defendants Meta Platforms, Inc, Meta Platforms Technologies, LLC, and Twisted Pixel Games, LLC*



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