

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re *Inter Partes* Review of:)
U.S. Patent No. 10,917,737)
Issued: Feb. 9, 2021)
Application No.: 16/558,088)
Filing Date: August 31, 2019)

For: **Defining a Zone with a HPED and Providing Binaural Sound in the Zone**

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 10,917,737**

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TABLE OF ABBREVIATIONS

Term	Abbreviation
wearable electronic device	WED
head mounted display	HMD
portable electronic device	PED
handheld portable electronic device	HPED
three-dimensional	3D
sound localization point	SLP
head-related transfer function	HRTF
virtual reality	VR
field of view	FOV

Exhibit List

Ex.	Description
1001	U.S. Patent No. 10,917,737 (“’737 patent”)
1002	U.S. Patent No. 10,917,737 File History (“’737 FH”)
1003	Declaration of Dr. Gregory Welch in Support of Petition for <i>Inter Partes</i> Review of the ’737 Patent (“Welch”)
1004	Curriculum Vitae of Dr. Gregory Welch
1005	U.S. Patent No. 9,851,786 (“Pedrotti”)
1006	U.S. Patent No. 8,520,872 (“Jang”)
1007	Durand R. Begault, <i>3-D Sound for Virtual Reality and Multimedia</i> , NASA/TM-2000-209606 (Aug. 2000) (“Begault”)
1008	U.S. Patent No. 9,041,622 (“McCulloch”)
1009	U.S. Patent No. 8,767,968 (“Flaks”)
1010	Declaration of Ingrid Hsieh-Yee in Support of Petition for <i>Inter Partes</i> Review of the ’737 Patent (“Hsieh-Yee”)
1011	<i>Curriculum Vitae</i> of Ingrid Hsieh-Yee
1012	International Patent Publication No. WO 2016/064435 (“Fei”)
1013	U.S. Patent No. 8,884,984 (“Flaks 984”)
1014	U.S. Patent No. 5,900,849 (“Gallery”)
1015	U.S. Patent Application Publication No. 2007/0173265 (“Gum”)
1016	U.S. Patent No. 2,955,156 (“Heilig”)
1017	U.S. Patent No. 9,544,706 (“Hirst”)
1018	U.S. Patent No. 10,095,031 (“Katz”)
1019	U.S. Patent No. 7,330,197 (“Kobayashi”)
1020	U.S. Patent No. 9,884,248 (“Koseki”)
1021	U.S. Patent Application Publication No. 2015/0119130 (“Lovitt”)
1022	U.S. Provisional Patent Application No. 62/289085 (“Mangiat”)
1023	U.S. Provisional Patent Application No. 62/309882 (“Marks”)
1024	U.S. Provisional Patent Application No. 62/340110 (“Martin”)

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Ex.	Description
1025	U.S. Patent Application Publication No. 2015/0302652 (“Miller 652”)
1026	U.S. Patent No. 10,509,466 (“Miller 466”)
1027	U.S. Patent Application No. 13/288350 (“Mount 350”)
1028	U.S. Patent Application Publication No. 2013/0141421 (“Mount 421”)
1029	U.S. Patent No. 9,703,369 (“Mullen”)
1030	U.S. Patent No. 9,767,618 (“Najaf-Zadeh”)
1031	U.S. Patent No. 9,037,468 (“Osman”)
1032	U.S. Patent No. 10,162,177 (“Pedrotti 177”)
1033	U.S. Patent No. 9,674,507 (“Pirchheim”)
1034	U.S. Patent No. 9,367,811 (“Ramachandran”)
1035	U.S. Patent No. 10,070,239 (“Romigh”)
1036	U.S. Patent Application Publication No. 2016/0124502 (“Sawyer”)
1037	U.S. Patent No. 9,301,069 (“Seligmann”)
1038	U.S. Patent No. 9,787,846 (“Srinivasan”)
1039	RESERVED
1040	U.S. Patent No. 10,114,465 (“Wan”)
1041	U.S. Patent No. 8,419,545 (“Yen”)
1042	U.S. Patent Application Publication No. 2012/0183161 (“Agevik”)
1043	U.S. Patent Application Publication No. 2017/0115488 (“Ambrus”)
1044	U.S. Patent No. 7,710,654 (“Ashkenazi”)
1045	U.S. Patent Application Publication No. 2016/0292924 (“Balanchandreswaran”)
1046	V.R. Algazi et al., <i>The CIPIC HRTF Database</i> , IEEE Workshop on Applications of Signal Processing to Audio and Acoustics 99-102 (2001) (“Algazi”)
1047	ASME International, <i>The Link Flight Trainer, A Historic Mechanical Engineering Landmark</i> (June 2000)
1048	Mark Billingham et al., <i>A Wearable Spatial Conferencing Space</i> , IEEE (1998) (“Billingham 1998”)

Ex.	Description
1049	Mark Billinghurst et al., <i>A Survey of Augmented Reality</i> , 8 Foundations and Trends in Human-Computer Interactions 73-272 (2015) (“Billinghurst 2015”)
1050	Douglas S. Brungart, <i>Near-Field Virtual Audio Displays</i> , IMAGE 2000 Conf., Scottsdale, Ariz., July 10-14, 2000 (“Brungart”)
1051	Anil Çamci et al., <i>Interactive Virtual Soundscapes: A Research Report</i> , ICMC 2015, Sept. 25-Oct. 1, 2015 (“Çamci”)
1052	Michael Cohen, <i>Integrating Graphic and Audio Windows</i> , 1 Presence 468-81 (Fall 1992) (“Cohen 1992”)
1053	Michael Cohen, <i>Throwing, Pitching and Catching Sound: Audio Windowing Models and Modes</i> , 39 Int. J. Man – Machine Studies 269-304 (1993) (“Cohen 1993”)
1054	John David N. Dionisio et al., <i>3D Virtual Worlds and the Metaverse: Current Status and Future Possibilities</i> , 45 ACM Computing Surveys 34 (June 2013)
1055	Steve DiPaola & David Collins, <i>A 3D Virtual Environment for Social Telepresence</i> , W. Comput. Graphics Symp., Mar. 24-27, 2002
1056	Kai-Uwe Doerr et al., <i>Evaluation of a Low-Cost 3D Sound System for Immersive Virtual Reality Training Systems</i> , 13 IEEE Transactions on Visualization & Comput. Graphics 204-12 (2007)
1057	Thomas Erickson et al., <i>Synchronous Interaction Among Hundreds: An Evaluation of a Conference in an Avatar-based Virtual Environment</i> , CHI 2001 Session: Meetings & Interaction Spaces, May 7-12, 2011 (“Erickson”)
1058	Oli Welsch, <i>Oculus Touch Is the Gold Standard in VR Control</i> , (June 24, 2015) https://www.eurogamer.net/oculus-touch-is-the-gold-standard-in-vr-control
1059	Foster, Cornell Univ. (SP2012), Lecture 25 Memory and Locality, https://www.cs.cornell.edu/courses/cs3110/2012sp/lectures/lec25-locality/lec25.html (“Foster”)
1060	Nathan Martz, <i>Spatial Audio Comes to the Cardboard SDK</i> , Google Developers Blog (Jan. 13, 2016) https://developers.googleblog.com/2016/01/spatial-audio-comes-to-

Ex.	Description
	cardboard-sdk.html
1061	John L. Hennessy & David A. Patterson, <i>Computer Architecture, A Quantitative Approach</i> (5th ed. 2012) (“Hennessy”) (excerpts)
1062	M.P. Hollier et al., <i>Spatial Audio Technology for Telepresence</i> , 15 BT Tech. J. 33-41 (Oct. 1997)
1063	Jason Jerald, <i>The VR Book: Perception and Interaction Design for Virtual Reality</i> (2015) (“VR Book”)
1064	Jiménez, TAMU Lecture 7: Caches, https://people.engr.tamu.edu/djimenez/taco/utsa-www/cs5513-fall07/lecture7.html (last visited Apr. 18, 2023)
1065	Are you Talking to Me? Job Simulator Wikia Fandom, https://jobsimulator.fandom.com/wiki/Are_You_Talking_to_Me%3F (last visited Apr. 4, 2023)
1066	Dean F. Kocian, <i>A Visually-Coupled Airborne Systems Simulator (VCASS) – An Approach to Visual Simulation</i> , Report No. AMRL-TR-77-31 (1977)
1067	Julian Löhr, <i>OpenAL-MOB With OpenFrameworks on Android</i> (Dec. 18, 2014), https://www.julianloehr.de/tag/ndk
1068	Bruce D. Lucas & Takeo Kanade, <i>An Iterative Image Registration Technique with an Application to Stereo Vision</i> , Proc 7th Intl Joint Conf on Artificial Intelligence (IJCAI) 674-79 (Aug. 24-28, 1981)
1069	David McGrath, <i>Huron – A Digital Audio Convolution Workstation</i> , 5th Australian Regional Convention 1-7 (Apr. 26-28, 1995) (“McGrath”)
1070	Timoni West, <i>UX Pointers for VR Design</i> (Nov. 10, 2015), https://medium.com/@timoni/ux-pointers-for-vr-design-dd52b718e19
1071	Todd Holmdahl, <i>BUILD 2015: A Closer Look at the Microsoft HoloLens Hardware</i> , Microsoft Blog (Apr. 30, 2015) https://blogs.windows.com/devices/2015/04/30/build-2015-a-closer-look-at-the-microsoft-hololens-hardware/ (“Microsoft, BUILD 2015”)
1072	Microsoft, Overview, <i>Spatial Audio</i> , Microsoft (Dec. 1, 2015)
1073	NSA, <i>Virtual Reality</i> , DOCID: 3929132 (1992)

Ex.	Description
1074	Xueni Pan et al., <i>Virtual Character Personality Influences Participant Attitudes and Behavior – An Interview with a Virtual Human Character about Her Social Anxiety</i> , 2 <i>Frontiers in Robots & AI</i> Article 1 (Feb. 2015)
1075	Tony Parisi, <i>Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web and Mobile</i> (2016) (“Parisi”)
1076	Randy Pausch et al., <i>Disney’s Aladdin: First Steps Toward Storytelling in Virtual Reality</i> , ACM 193-205 (1996) (“Pausch”)
1077	Tabitha C. Peck et al., <i>An Evaluation of Navigational Ability Comparing Redirected Free Exploration with Distractors to Walking-in-Place and Joystick Locomotion Interfaces</i> , Proc IEEE Virtual Real Conf. 55-62 (Mar. 19, 2011) (“Peck”)
1078	Glenn Chapman, <i>Google Glass Available in US as of April 15</i> , Phys.Org (Apr. 10, 2014) https://phys.org/news/2014-04-google-glass-april.html
1079	Lars Klint, <i>Holographic Programming: A HoloLens How-To in a Mixed Reality World</i> , PluralSight (May 2016)
1080	Spanner Spencer, <i>Sixense Picks Up CES Awards for Virtual Reality Controller</i> (Jan. 13, 2015) http://www.pocketgamer.biz/news/60642/sixense-picks-up-ces-awards-for-virtual-reality-controller
1081	Qualcomm, <i>What’s So Special About the Digital Signal Processor?</i> , Qualcomm OnQ Blog (Dec. 5, 2013)
1082	Francisco Cheng, <i>Mobile Processors 101: Why Smartphones are Smarter with an All-In-One Processor</i> , Qualcomm OnQ Blog (June 12, 2013)
1083	RAF Museum, <i>Flight Simulation and Synthetic Trainers</i> , https://www.rafmuseum.org.uk/research/online-exhibitions/taking-flight/historical-periods/flight-simulation-and-synthetic-trainers/ (last visited Apr. 4, 2023)
1084	VisiSonics Corp., <i>Manual for VisiSonics’ RealSpace3D Audio Unity Plugin</i> (Nov. 17, 2015)

Ex.	Description
1085	Paul James, <i>Watch Halo Played on Microsoft HoloLens in Augmented Reality</i> , RoadtoVR (Dec. 7, 2015), https://www.roadtovr.com/watch-halo-played-on-microsoft-hololens-in-augmented-reality/
1086	Paul James, <i>Samsung Gear VR Gets Positional Tracking Via Sixense STEM, Announced at SFVR (Video)</i> , RoadtoVR (Nov. 8, 2014), https://www.roadtovr.com/samsunng-gear-vr-gets-positional-tracking-via-stem-demod-sfvr-video/
1087	Warren Robinett & Richard Holloway, <i>The Visual Display Transformation for Virtual Reality</i> , 4 Presence 1-23 (1995)
1088	Eric E. Sabelman & Roger Lam, <i>The Real-Life Dangers of Augmented Reality</i> , North American, Spectrum.ieee.org (July 2015) (“Sabelman”)
1089	<i>Using the Oculus Rift with Second Life</i> , Linden Labs Blog (May 21, 2014), http://community.secondlife.com/blogs/entry/1275-using-the-oculus-rift-with-second-life/
1090	Jianbo Shi and Carlo Tomasi, <i>Good Features to Track</i> , IEEE Conf. on Comput. Vision & Pattern Recognition (CVPR94) (June 1994) (“Shi”)
1091	M. Slater et al., <i>Acting in Virtual Reality</i> , ACM 103-10 (2000) (“Slater”)
1092	<i>Characteristics of Flight Simulator Visual Systems</i> , NASA Technical Memorandum 81278 (Irving C. Statler ed., 1981)
1093	Ivan E. Sutherland, <i>A Head-Mounted Three Dimensional Display</i> , Fall Joint Comput. Conf. 757-764 (1968) (“Sutherland 1968”)
1094	Frederic Lardinois, <i>HoloLens Hands-On: How We Built An App For Microsoft’s Augmented Reality Headset</i> , TechCrunch (May 2015)
1095	Stuart Dredge, <i>Virtual World Second life to Be Reincarnated, with Oculus Rift</i> , The Guardian (June 24, 2014) https://www.theguardian.com/technology/2014/jun/24/second-life-oculus-rift-virtual-world
1096	Unity Manual: Audio Spatializer SDK (2020), https://docs.unity.cn/530/Documentation/Manual/AudioSpatializerSDK.html
1097	Ian Hamilton, <i>In a Cartoon World, Holojam Shows Participants a Slice of Space-Time</i> , Upload VR (Aug. 4, 2015),

Ex.	Description
	https://www.uploadvr.com/holojam-shows-participants-slice-space-time/
1098	Joe Durbin, <i>Google Cardboard Now Offers Spatial Audio</i> , UploadVR (Jan. 15, 2016)
1099	Dean Takahashi, <i>Second Life Creator Linden Lab Starts Testing Its Virtual-Reality World: Project Sansar</i> , Venture Beat (Aug. 18, 2015), https://venturebeat.com/games/linden-lab-starts-testing-its-virtual-reality-world-projet-sansar/
1100	Dean Takahashi, <i>Unreal Engine’s Latest Innovation Is About Building Games While Inside Virtual Reality</i> , Venture Beat (Feb. 4, 2016), https://venturebeat.com/games/epic-games-lets-you-design-your-game-inside-vr-with-new-edition-of-unreal-engine-editor
1101	Dean Takahashi, <i>Final Approach Is an HTC Vive VR Game that Turns You into a Kid Playing with Toy Airplanes</i> , Venture Beat (Jan. 29, 2016), https://venturebeat.com/games/final-approach-is-an-htc-vive-vr-game-that-turns-you-into-a-kid-playing-with-toys
1102	Dean Takahashi, <i>Valve’s Virtual Reality Apps with the HTC Vive Headset Won’t Make You Seasick</i> , Venture Beat (May 2, 2015), https://venturebeat.com/games/valves-virtual-reality-apps-with-the-htc-vive-headset-wont-make-you-seasick/
1103	Greg Welch et al., <i>High Performance Wide-Area Optical Tracking: The HiBall Tracking System</i> , 10 Presence: Teleoperators and Virtual Environments 1-22 (Feb. 2001) (“Welch 2001”)
1104	Elizabeth M. Wenzel et al., <i>A Virtual Display System for Conveying Three-Dimensional Acoustic Information</i> , Proc. Hum. Factors Soc’y – 32nd Ann. Meeting (1988) (“Wenzel 1988a”)
1105	Elizabeth M. Wenzel et al., <i>Development of a Three-Dimensional Auditory Display System</i> , 20 SIGCHI Bull. 52-57 (Oct. 1988) (“Wenzel 1988b”)
1106	Elizabeth M. Wenzel et al., <i>Localization with Non-Individualized Virtual Acoustic Display Cues</i> , ACM (1991) (“Wenzel 1991”)
1107	Zhiying Zhou, <i>An Experimental Study on the Role of Software Synthesized 3D Sound in Augmented Reality Environments</i> , 16 Interacting with Computers 989-1016 (2004) (“Zhou”)

Ex.	Description
1108	Wikipedia, <i>Job Simulator</i> https://en.wikipedia.com/wiki/Job_Simulator
1109	Cardboard Unity (2015), https://github.com/jkammerl/cardboard-unity/blob/master/Cardboard/Editor/CardboardAudioSourceEditor.cs
1110	Aurale R. DeRuyck & Jack Kuipers, <i>An Electromagnetic Position Sensor</i> , Report No. AFAL-TR-73-281 (Nov. 30, 1973)
1111	Dmitry N. Zotkin et al., <i>Rendering Localized Spatial Audio in a Virtual Auditory Space</i> , 6 IEEE Transactions on Multimedia 553-64 (Aug. 2004) (“Zotkin”)
1112	Ronald T. Azuma, <i>A Survey of Augmented Reality</i> , 6 Presence 355-85 (1997)
1113	Gary Bishop & Henry Fuchs, <i>The Self-Tracker: A Smart Optical Sensor on Silicon</i> , 1984 Conf. on Advanced Rsch. in VLSI 65-73 (Jan. 23, 1984) (“Bishop”)
1114	Mark R. Mine, <i>Working in a Virtual World: Interaction Techniques Used in the Chapel Hill Immersive Modeling Program</i> , TR96-029, Univ. N.C. (August 1, 1996) (“Mine 1996”)
1115	Mark R. Mine, <i>ISAAC: A Meta-CAD System for Virtual Environments</i> , 29 Computer-Aided Design 547-53 (1997) (“Mine ISAAC 1997”)
1116	Mark Raymond Mine, <i>Exploiting Proprioception in Virtual-Environment Interaction</i> (1997) (Ph.D. dissertation, Univ. N.C.) (“Mine Exploiting Proprioception 1997”)
1117	Adrienne Vincent-Phoenix, <i>Step into the DISH – A Visit to Imagineering’s Digital Immersive Showroom</i> , MousePlanet (June 5, 2012), https://mouseplanet.com/9994/Step_into_the_DISH_a_visit_to_Imagineerings_Digital_Immersive_Showroom
1118	Ian Hamilton, <i>How They Did It: Cars Land’s Virtual Reality</i> , Orange Cnty. Reg., June 25, 2012, https://www.ocregister.com/2012/06/25/how-they-did-it-cars-lands-virtual-reality/
1119	Gregory F. Welch, <i>Hybrid Self-Tracker: An Inertial/Optical Hybrid Three-Dimensional Tracking System</i> (1995) (dissertation proposal

Ex.	Description
	Univ. N.C.) (“Welch 1995”)
1120	Steven M. Kaplan, <i>Wiley Electrical and Electronics Engineering Dictionary</i> 71 (2004)
1121	Plaintiff’s Infringement Contentions, Exhibit 16, <i>Eight Khz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575 (W.D. Tex. Mar. 3, 2023)
1122	Amended Complaint for Patent Infringement and Demand for Jury Trial, <i>Eight Khz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575-ADA, (W.D. Tex. Oct. 10, 2022)
1123	Mark Billinghurst et al., <i>The MagicBook – Moving Seamlessly Between Reality and Virtuality</i> , IEEE Computer Graphics and Applications, 6-8 (2001) (“Billinghurst 2001”)
1124	Jaka Sodnik & Sašo Tomažič, <i>Spatial Auditory Human-Computer Interfaces</i> , Springer Briefs Comput. Sci. (2015) (“Sodnik”)
1125	U.S. Patent No. 9,392,212 (“Ross”)
1126	Defendants’ Opening Claim Construction Brief, <i>Eight kHz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575 (W.D. Tex. Apr. 12, 2023), ECF No. 83
1127	Plaintiff’s Claim Construction Reply Brief, <i>Eight kHz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575 (W.D. Tex. May 3, 2023), ECF No. 92
1128	Declaration of Durand R. Begault, Ph.D., <i>Eight kHz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575 (W.D. Tex. May 3, 2023), ECF No. 92-7
1129	RESERVED
1130	RESERVED
1131	U.S. Patent No. 5,173,944 (“Begault 944”)
1132	U.S. Patent No. 5,438, 623 (“Begault 623”)
1133	Karl-Petter Akesson & Kristian Simsarian, <i>Reality Portals</i> , ACM (1999)
1134	Mark Mine, <i>Towards Virtual Reality for the Masses: 10 Years of Research at Disney’s VR Studio</i> , Eurographics Ass’n (2003) (“Mine 2003”)

Ex.	Description
1135	Greg Welch & Eric Foxlin, <i>Motion Tracking: No Silver Bullet, but a Respectable Arsenal</i> , IEEE Computer Graphics and Applications 24-28 (2002) (“Welch, <i>No Silver Bullet</i> ”)
1136	Deposition transcript of Durand Begault, Ph.D., dated May 22, 2023 in Eight Khz, LLC v. Meta Platforms, Inc., No. 6:22-cv-00575-ADA (“Begault Dep.”)
1137	Dave Smith, <i>Three-Dimensional Audio Makes Virtual Reality So Much Better It’s Crazy</i> , BUSINESS INSIDER (Apr. 3, 2015, 1:06PM), https://www.businessinsider.com/virtual-reality-the-importance-of-3d-positional-audio-2015-4
1138	Mona Lalwani, <i>Surrounded by Sound: How 3D Audio Hacks Your Brain</i> , THE VERGE (Feb. 12, 2015, 10:30AM), https://www.theverge.com/2015/2/12/8021733/3d-audio-3dio-binaural-immersive-vr-sound-times-square-new-york
1139	Ben Kuchera, <i>Google Cardboard Adds ‘Inexpensive’ Spatial Audio to Its SDK</i> , POLYGON (Jan. 13 2016, 12:00PM EST)
1140	Sutherland, <i>Sketchpad: A Man-Machine Graphical Communication System</i> , Thesis, Massachusetts Institute of Technology (1963) (“Sutherland 1963”)

I. Introduction

Meta Platforms, Inc., Meta Platforms Technologies, LLC, and Twisted Pixel Games, LLC (collectively, “Petitioners”) request IPR of claims 1-20 of U.S. Patent No. 10,917,737 (Ex.1001).

The ’737 patent relates generally to systems and methods for selecting locations where three-dimensional (3D) sound, i.e., binaural sound, localizes to listeners. ’737 patent, 1:20-27. The ’737 patent acknowledges that 3D sound localization was known and enabled users to “communicate more efficiently with electronic devices, software programs, and processes.” *Id.* 1:7-12. Thus, it focuses on potential applications of 3D sound, and in particular, virtual zones that can contain one or more sound localization points (SLPs)—locations where a listener localizes sound (*id.* 65:23-40). The challenged claims, specifically, are directed to tracking a portable electronic device (PED or HPED if handheld) with a wearable electronic device (WED) worn on a user’s head to define a “zone,” and designating SLPs therein. *Id.* 66:5-68:55.

The challenged claims run straight into the prior art. As the Pedrotti reference discussed in both grounds shows, it was known before the ’737 patent’s earliest possible priority date (June 2016) that systems with tracked handheld controllers and head mounted displays could define zones around users, for example, to “assist[] a user in remaining in a selected area” in “a virtual world,” e.g., a “safe area” (zone)

bound by “a virtual fence” that appears to “provid[e] a warning that the user is about to move out of the selected area.” Pedrotti, Title, 4:32-44. Likewise, it was known that binaural sound should be used in virtual environments to give users a better sense of reality and immersivity, including with virtual objects that users can control, e.g., by moving and assigning (i.e., designating) such objects’ positions (SLPs). This is shown by the Jang and Begault references addressed with Pedrotti in Ground 1, and the McCulloch and Flaks references discussed with Pedrotti in Ground 2. Any alleged differences between this art and the challenged claims amount to obvious and trivial variations of common features in virtual environments.

Petitioners ask the Board to institute review and find the challenged claims unpatentable.

II. Identification of Challenges

Ground 1: Claims 1-20 are obvious over Pedrotti (Ex.1005) in view of Jang (Ex.1006), and further in view of Begault (Ex.1007).

Ground 2: Claims 1-20 are obvious over McCulloch (Ex.1008) in view of Pedrotti, and further in view of Flaks (Ex.1009).

III. Background

A. The ’737 Patent

The ’737 patent is directed to defining zones and SLPs in three-dimensional space, assigning sounds to those zones and SLPs, and processing sounds so they localize to assigned zones and SLPs. ’737 patent, 1:22-26, 2:36-3:58, 47:29-40,

65:23-24, Fig. 13E (user surrounded by differently shaped zones). According to the '737 patent, these zones “represent locations where a user perceives sound to originate or localize” (*id.* 49:23-33) and can “assist the listener in organizing different sounds” by allowing sounds to be processed with “head related transfer functions (HRTFs)” so they are perceived to originate from different locations (SLPs) in the zones. *Id.* 10:57-11:38, 17:7-15, 19:47-67, 24:1-4, 39:21-63. For example, telephone calls may be assigned to, and processed to originate from SLPs in, one zone, and music may be assigned to a separate zone. *Id.* 11:4-16; Welch (Ex.1003) ¶¶27-33.

B. POSAs

A person of ordinary skill in the art (“POSA”) as of the '737 patent’s earliest alleged priority date (June 10, 2016)¹ would have had a Bachelor’s degree in computer science/engineering, or a related field, and at least two years of industry experience, or academic research experience, in virtual/augmented reality, including visual and audio modeling and rendering. Additional education can compensate for less experience, and vice-versa. Welch ¶¶34-40.

¹ Petitioners reserve the right to challenge this priority date in other proceedings.

C. Claim Construction

The prior art relied on in this Petition discloses the subject matter of the challenged claims under any reasonable construction, including their plain meaning.

Additionally, Patentee contends in district court that limitations reciting “processing, by a processor, sound with... HRTFs,” e.g., limitations 1[d] and 14[c],² should be construed by plain meanings and “Section 112(f) does not apply.” Ex.1127, 24-38. Solely for this IPR, Petitioner adopts Patentee’s plain-meaning positions for such limitations.³

IV. Ground 1: Claims 1-20 Are Unpatentable Over Pedrotti, Jang, and Begault

Challenged claims 1-20 are unpatentable over Pedrotti in view of Jang, and further in view of Begault, for the reasons discussed below.

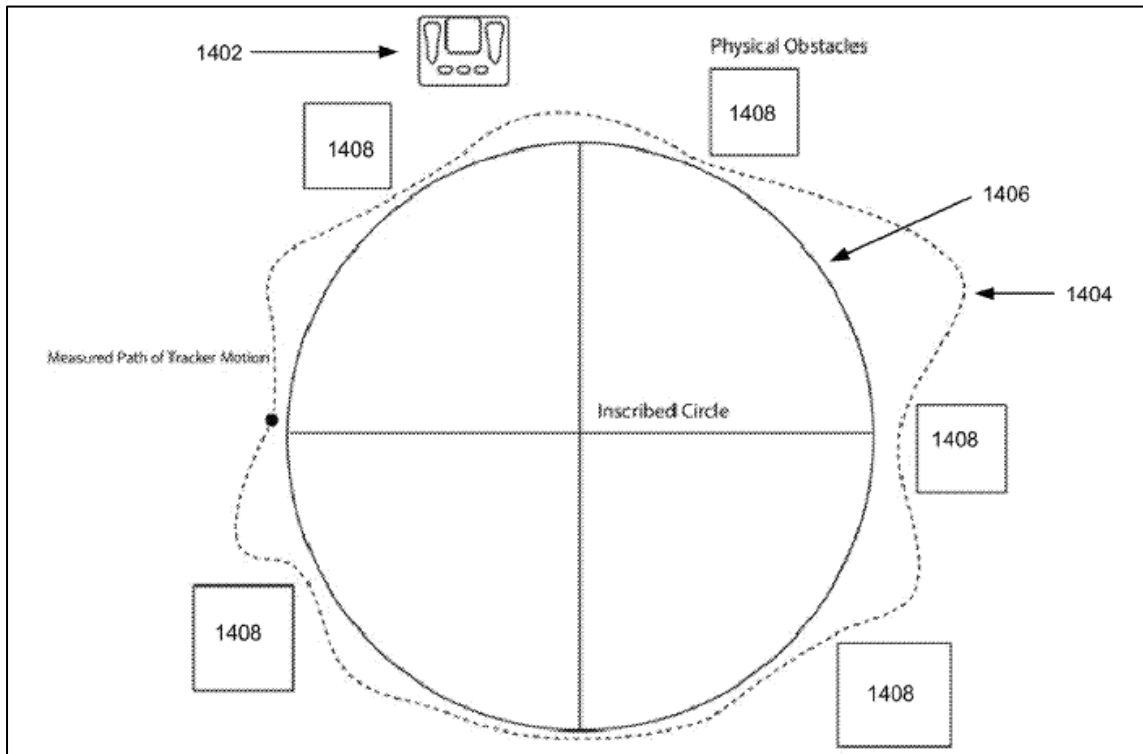
A. Overview of Pedrotti

Pedrotti, filed in July 2015 and issued in December 2017, is § 102(a) prior art and was not considered during prosecution.

² The “Claims Appendix” attached to this Petition reproduces challenged claims with bracketed cross-referencing identifiers.

³ Petitioners reserve the right to argue alternative constructions in other proceedings, including that claims are indefinite—and do so in district court.

Pedrotti taught ways to “assist[] a user in remaining in a selected area” in virtual environments. Pedrotti, Title. It disclosed methods for defining an area’s boundaries, including boundaries that “can be defined, for example, by having the user walk around a perimeter chosen by the user with” a “tracker[]”:



Id. Fig. 14, 14:6-15:3, Figs. 12-13.

In Pedrotti’s virtual environments, a processor, which may be “in the HMD,” tracks the positions and orientations of a “HMD tracker” and “trackers in the physical controllers,” so it “knows where the user’s head and hands are located.” *Id.* 4:37-44, 12:31-39, 15:4-39, 16:22-26, Fig. 15. The “processor causes the HMD to display a warning, such as a virtual fence, to alert the user if the user approaches to within a preselected distance of the boundary,” e.g., to “avoid[s] collisions.” *Id.*

Abstract, Fig. 11, 2:7-12, 11:43-12:15-13:33. Pedrotti's teachings apply to "HMDs that block the user's view of all or only part of the physical world." *Id.* 16:14-19; Welch ¶¶148-159.

B. Overview of Jang

Jang, issued in August 2013, is § 102(a) prior art and was not considered during prosecution.

Jang taught that VR systems can provide "a high degree of realism" through "manufactured sensory inputs." Jang, 1:28-33. For example, in a VR game, "life-like images and sounds may be generated," with images "three-dimensionally realized" with an "HMD" and sound produced through "a localization technique capable of expressing the virtual location," e.g., sound processed to "express directionality" using HRTFs. *Id.* 1:35-56.

Jang disclosed that, in VR, movement need not "precisely mimic the real world," and users can "shift between virtual spaces without having to portray the passage of distance or time." Jang, 1:57-67. Such shifts "may occur in various ways," e.g., through "key input of [a] user," or when a "scene change" is otherwise detected "due to space shift." *Id.* 9:11-17; Welch ¶260 (discussing known VR navigation methods). Jang taught techniques providing "a higher sense of realism" during these shifts. Jang, 2:1-11.

Specifically, Jang disclosed processing sound in “sound areas” divisible into “focus” areas, e.g., a user’s visual perspective, and “un-focus” areas. *Id.* 1:18-23, 2:35-47, 3:39-48, 8:25-36, Fig. 2. These areas are modifiable based on “characteristics and/or topography of the virtual area at which [a] character is located,” “contain any number of virtual objects represented by” “audio and visual data,” and can be sub-divided “according to a predetermined priority.” *Id.* 8:36-49, 4:25-39, 9:47-65, cls. 4, 10.

Jang taught that when a space shift occurs, e.g., from a virtual basketball court to a conference room, “sensory output” for “the focus area of the second virtual space” can be generated before “sensory output” for “the non-focus area.” *Id.* 4:6-9, Fig. 5; Welch ¶¶160-173.

C. Overview of Begault

Begault, published in 2000, is § 102(a) prior art and was not considered during prosecution. Hsieh-Yee ¶¶9-64; Begault Dep. (Ex.1136) 222:21-223:17.

Begault described processes for producing “3-D sound,” “spatialized sound,” and “binaural audio,” explaining these terms refer to techniques that use digital filters to position sounds in “virtual space.” Begault, x. Begault taught that sound should have an “interactive, spatial character” because one can “work more effectively within a VR environment if actions [a]re accompanied by appropriate sounds that seemingly emit from their proper locations.” *Id.* 12-13.

Begault described in detail HRTF processing for binaural sound (*id.* ch. 2) and taught that such sound can be “controlled by the user,” including through interfaces “for arranging [] various sound inputs in virtual auditory space.” *Id.* 172-74, Fig. 5.12; Welch¶¶174-186.

D. Motivations to Combine

POSAs would have known and been motivated to combine Pedrotti’s systems and methods with Jang’s and Begault’s sound processing techniques. Welch¶¶210-225.

Pedrotti, Jang, and Begault are analogous art—all relate to improving virtual environments comprising virtual objects with which users interact. Pedrotti, 1:8-10; Jang, 1:18-30; Begault, 10; Welch¶¶211, 219. Pedrotti discloses “sight and sound” as the “most commonly used” senses in virtual environments (Pedrotti, 1:14-20) but does not address sound processing. POSAs reading Pedrotti thus would have been motivated to look to references, like Jang and Begault, which disclose advantageous sound processing techniques providing “a higher sense of realism” and enabling “a rich auditory environment.” Jang, 1:42-56, 2:9-11, 2:26-28; Begault, 10-11, 13. Adding Jang and Begault’s sound processing techniques would have amounted to no more than applying known techniques (e.g., binaural sound processing) to a known device (Pedrotti’s HMD) ready for improvement to yield predictable results (spatialization of sound for an immersive VR experience). Welch¶¶212-213, 220.

POSAs would have implemented Pedrotti's HMD with Jang and Begault's sound processing techniques for several reasons. POSAs would have understood that providing binaural sound would enhance the sense of "presence" for users, making the VR experience more immersive. A virtual environment and its images seem more realistic when they have realistic and compelling sound. Conversely, when sound does not match imagery, the optical illusion begins to break down, creating disbelief and detracting from users' sense of presence or immersion. Ex.1138; Ex.1137. Further, binaural sound was known to enhance perception of space, distance, and size within virtual environments. "An accurate spatial reproduction of sound can significantly enhance 3D perception," enabling users to better identify and localize objects. Ex.1124, 54; Welch¶¶212-214. Also, binaural sound, as disclosed by Jang and Begault, was a computationally efficient way of achieving these goals. Begault, 11 (spatial audio is "easier to accomplish"); Ex.1139 (spatial audio "inexpensive"); Welch¶¶221-224.

Additionally, Pedrotti and Jang are Sixense and Samsung patents, respectively. POSAs would have known that both companies were working on VR systems, including in concert and on complementary technologies. Welch¶¶215-217; Ex.1086 (Samsung gets VR tracking from Sixense); Ex.1080 (Sixense "demos on Samsung Gear VR").

Furthermore, POSAs would have reasonably expected to succeed in combining the teachings of these references, which disclose well-known hardware, such as HMDs and controllers, and methods of using that hardware, e.g., to spatialize binaural sound, that were commonly known. §§IV.A-IV.C; McCulloch, 21:21-38 (describing an HMD with a binaural sound engine). To POSAs, implementing the audio processing described in Jang and Begault in Pedrotti's HMD would have been well within a POSA's skill and common sense and obvious to try. Welch¶¶221-224.

E. Claim 1

1. 1[pre]: A Method Executed By Electronic Devices

Claim 1's preamble recites: "A method executed by one or more electronic devices, the method comprising." Pedrotti disclosed methods implemented with electronic devices, including a "HMD" and "handheld controller[s]." Pedrotti, 2:27-59. Welch¶¶226-228.

2. 1[a]: WED Tracking a HPED Defining a Zone

Limitation 1[a] recites:

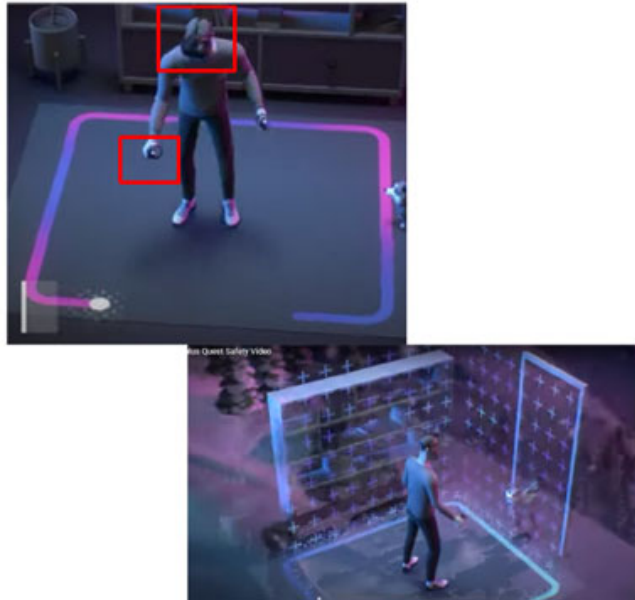
tracking, with a wearable electronic device (WED) worn on a head of a user, movement of a handheld portable electronic device (HPED) held in a hand of the user such that the movement of the HPED defines a size and a shape of a three-dimensional (3D) zone that extends from a physical floor and around the user.

Users of Pedrotti's system "wear a head-mounted display (HMD)" (WED), and "hold a handheld controller" (HPED). Pedrotti, 2:44-47. Pedrotti's handheld controller includes a "tracker," which "provides information regarding a position of the handheld controller." *Id.* 2:46-49, 15:7-12, 4:49-5:24 ("known" "trackers" can be used). Pedrotti's system also includes a processor that tracks the controllers, determining "the position of the handheld controller... using information from the controller tracker." *Id.* 2:49-57. This processor, which may be "in the HMD," "knows where the user's head and hands are located." *Id.* 12:29-39, 16:22-24. Thus, Pedrotti's HMD tracked (or at a minimum obviously tracked) movement of an HPED. Welch ¶¶229-232.

Pedrotti's HMD-tracked controller "defines a size and a shape of a three-dimensional (3D) zone that extends from a physical floor and around the user." Pedrotti disclosed that its system can determine "a boundary of a selected area" in a virtual environment, so users "may move freely" and without contacting "obstacles." Pedrotti, 2:49-51, 4:32-36. That boundary "can be defined, for example, by having the user walk around a perimeter chosen by users with one of the trackers," e.g., the trackers in users' controllers, "to define the outer boundary of [the] selected area." *Id.* 14:56-62. "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." *Id.* 14:62-65, 15:13-22.

After Pedrotti's boundary is defined, e.g., by the "measured path of tracker motion" (*id.* Fig. 14), and users are in "the virtual world" (for example, "playing a game"), when "the processor determines from the position of the handheld controller that the handheld controller is within a preselected distance of the boundary," it instructs the HMD to display "a visual warning to the user," which can be "in the form of grid lines such as a virtual fence." *Id.* 11:43-55, 15:30-37, Figs. 11, 14-15. Thus, movement of Pedrotti's HMD-tracked handheld controller defines a size and shape of a 3D zone—Pedrotti's "safe area" in a virtual world, bound by Pedrotti's boundary and its virtual fence—which extends (or at a minimum obviously extends) from a physical floor and around a user. *Id.* Fig. 10 ("floor 1010"), Fig. 11 ("virtual fence 1114"), Fig. 14 ("boundary 1404"); *see also id.* 13:17-27 ("fence may be rendered as projected texture" on "3D geometry"); Welch ¶¶132-144, 233-236 (discussing Pedrotti and other prior art, e.g., Ross (Ex.1125), disclosing VR HMDs that track user movement and controllers, to "create and/or manipulate a boundary").

Notably, Pedrotti's zone is nearly identical to features that Patentee contends in district court satisfy limitation 1[a]'s requirement of a "three-dimensional (3D) zone that extends from a physical floor and around a user":



Ex.1121, 3; Welch¶237.

3. 1[b]: Designating an SLP

Limitation 1[b] recites: “designating, with the HPED held in the hand of the user, a sound localization point (SLP) in empty space in the zone above the physical floor from where binaural sound originates to the user.”

a. Characters Moved by Controllers

In the parallel district court action, Patentee contends that limitation 1[b], including the recited “designating” of an SLP, requires only “a game character” being “moved by direction of [an] HPED,” asserting that an “SLP will likewise move along with the corresponding location of the game character.” Ex.1121, 4. Under this interpretation, limitation 1[b] would have been obvious in view of Pedrotti and Jang, including because HPEDs moving sound-producing characters was a matter of

common knowledge before June 2016. Welch¶¶238-254; Ross, 17:22-18:35 (users “moving objects and/or characters”).

Pedrotti disclosed using an HPED to move virtual objects in its zone, including in empty space above a physical floor. Pedrotti’s controllers are “use[d] to control certain actions or events in the virtual world,” including by “moving” virtual objects such as virtual weapons and sports equipment. Pedrotti, 4:4-15, 5:25-36, 8:14-35, 9:26-52, 16:33-42, Fig. 8 (virtual sword 802 in empty space in zone, above floor).⁴ Welch¶243.

POSAs further would have known to associate binaural sounds with Pedrotti’s VR objects and have sound move with them because these were fundamental features of VR before June 2016. Welch¶¶241, 251-253 (collecting references, such as Ross, disclosing interactions with, and control of, VR objects, for example, “a character” “walk[ing] the user through a scene in virtual space and point[ing] things out”). Indeed, Dr. Durand Begault—the author of the Begault reference and Patentee’s expert in district court—confirmed that, before 2014, “it was known that people in virtual reality environments could point their controllers at virtual objects

⁴ The ’737 patent defines “empty space” as any “location that is not occupied by a tangible object.” ’737 patent, 65:4-5.

to select and move them, and then a virtual object's sound would move with it.” Begault Dep., 195:12-196:10; *id.* 135:6-19; Welch¶¶241, 251-253.

Further, Jang confirms the obviousness of moving binaural sound-producing virtual objects, e.g., characters. Jang disclosed “game joystick[s]” and “controller[s]” and that a user “may see, hear, and otherwise sense the virtual environment” and “interact with” it, including “other avatars, characters, objects, or features.” Jang, 1:35-38, 6:35-38, 6:44-47. And Jang taught that its sound processing “check[s] sound source information on other characters and other objects” and provides localized audio for “sound sources” “according to the[ir] relative locations”—i.e., binaural sound at SLPs. *Id.* 7:24-59; *id.* 1:42-56, 8:65-9:1 (using “localization technique capable of expressing the virtual location” of “a sound-generating object”); Welch¶¶245-254 (additional references show POSAs would have known to use binaural sound to “provide[] a sense of where sounds are coming from in a 3D space” because “[a]uditory cues play a crucial role in... VR”).

b. HPEDs Used to Assign SLPs

Limitation 1[b] also would have been obvious over Pedrotti and Jang, or over Pedrotti, Jang, and Begault, if it is interpreted such that the recited “designating” of

an SLP requires an affirmative assignment of same.⁵

Jang disclosed processing and producing sound in “sound areas.” Jang, 2:32-47, 2:60-3:4. Jang taught that these areas may be sub-divided according to a “predetermined priority” or “scheme” and contain “a plurality of sensory sources,” including “audio sources.” *Id.* 4:19-39, 6:51-59, 8:46-58, 9:47-10:5. This allows Jang’s system to better manage VR space shifts. *Id.* 6:47-59, 11:1-16, 11:47-63. “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,” with sensory data for focus areas processed first. *Id.* 11:64-12:16.

POSAs reading Jang would have known and been motivated to set, author, and control the predetermined priorities for sound areas by designating locations from where sound sources will produce sound (i.e., SLPs). Welch¶¶255-262, 267-270. For example, in Jang’s basketball court, a virtual team’s bench and stands could be set as a “focus area,” with priority characters and sound-generating objects (e.g., an announcer or a pep band) assigned to locations therein (SLPs) while lower priority

⁵ See, e.g., ’737 patent, 1:23-26 (“Sounds are assigned to different zones” and “SLPs,” and are processed to an “assigned zone” or “assigned SLP”).

characters (e.g., an airhorn in the stands) can be outside the “focus area.” *Id.*¶263. Similarly, in Jang’s conference room, one side of the room could be set as a “focus area,” with priority characters and other sound-generating objects (e.g., certain attendees and a monitor) assigned to locations therein (SLPs). *Id.*¶264. These types of divisions of sensory elements in different zones in VR environments were well known. *Id.*¶¶114-131; VR Book (Ex.1063) 254-55 (“Center of Action” setups “split[] the world... into different zones”); Ross, 14:53-15:28, 15:29-55, 20:22-21:51 (VR content displayed based on “a position of the user within the virtual space,” e.g., when a user moves “across a boundary”), 22:17-56. As Begault taught, “virtual spatial hearing with a 3-D sound system involves the positioning of each of a number of sources.” Begault, 4. And as Dr. Begault testified, this means that “if you use a 3D sound system, oftentimes a number of sound sources are positioned to different locations.” Begault Dep., 225:15-226:13; *id.* 135:6-25. POSAs also would have known that with Jang’s sound system, binaural sound would originate from designated locations—as discussed, Jang disclosed the use of localized binaural sound. Welch¶¶266.

Furthermore, Begault disclosed methods for assigning positions for binaural sound (SLPs) that POSAs would have recognized as useful for managing Jang’s sound areas. Welch¶¶271-280. For example, Begault taught that sound can be “controlled by [a] user” through “audio spatial mapping,” which—as in Jang—

“correspond[s] to a prioritization scheme.” Begault, 172. And Begault disclosed simple interfaces for “arranging [] various sound inputs in virtual auditory space in a manner configurable by each individual listener” and providing “commands” to an associated “multiinput, 3-D sound spatialization subsystem,” i.e., a system for producing binaural sound. *Id.* 172-73, Fig. 5.12; §IV.C. Thus, Begault confirms that it would have been obvious to implement a Pedrotti-Jang system such that users could and would use Pedrotti’s handheld controller (an HPED held in the hand of the user) to designate locations for the production of Jang’s spatialized sounds (SLPs from where binaural sound originates to a user), for example with an interface as Begault described. Welch¶¶278-279; Ross, 21:52-23:45 (disclosing GUIs for the “creation, customization, and/or adjustment of” VR content).

POSAs would have known that, in a Pedrotti-Jang system, or a Pedrotti-Jang-Begault system, Pedrotti’s controllers—which control and move virtual objects (§IV.E.2)—could and would be used for the designation of sound areas and sound source locations (SLPs) through routine selection patterns such as pointing at, selecting, and moving sound areas and sources. Welch¶¶72-86; VR Book, 327 (“Pointing Pattern is one of the most fundamental and often-used patterns for selection”); Ross, 7:51-62, 14:44-52, 22:17-29 (“controller (e.g., a pointer)” used to control VR “content, the fields of view, [and] view boundaries”); Begault Dep., 195:12-196:10.

Sound source locations (SLPs) designated as described above would be, or at a minimum obviously would be, “in empty space in the zone above the physical floor”—in the VR environment within Pedrotti’s zone. Welch¶265.

4. 1[c]: Tracked HPED Provides Location of SLP

Pedrotti and Jang, or Pedrotti, Jang, and Begault render obvious limitation 1[c], which recites:

tracking, with the WED worn on the head of the user, the HPED held in the hand of the user such that the HPED provides a location to the WED of the SLP in empty space in the zone above the physical floor from where the binaural sound originates to the user.

Pedrotti taught tracking controllers (HPEDs) with its HMD (a WED). §IV.E.2. POSAs would have known and understood that when a Pedrotti controller is used to move virtual objects, for example to position sound sources in a Pedrotti-Jang (or Pedrotti-Jang-Begault) system, that action would (or at a minimum obviously would) provide Pedrotti’s HMD the locations to which the virtual objects were moved and/or assigned (SLPs). Welch¶¶281, 286-289. Pedrotti’s processor, “in the HMD,” “us[es] information” it receives “from the controller tracker[s],” including to “generate and output” appropriate instructions to the HMD. Pedrotti, 2:49-59. Thus, POSAs would have known that Pedrotti’s processor could and would receive locations of SLPs provided by Pedrotti’s controllers, so binaural sounds could be processed to originate from assigned locations, which, as noted, would obviously

include locations in “empty space” and “above a physical floor” in Pedrotti’s zone. Welch¶¶290-291; Jang, 4:19-39 (generating sensory outputs based on set “priority”), 6:39-59; §IV.E.3.

For example, if Pedrotti’s handheld controller designates locations for an announcer or a pep band in Jang’s virtual basketball court, the HPED making these designations could and would provide the locations for these sensory elements’ binaural sound. Welch¶¶292; Jang, 10:32-43 (“Ideally, basketball court sound 515 including sound of people 501a to 501d and sound of a speaker 503 in the basketball court 500 is first provided as shown in (a) of Fig. 5”), Fig. 5. As another example, if Pedrotti’s controller controls an interface facilitating “spatial audio mapping,” as described by Begault, that too could and would provide positions for the generation of binaural sound. Welch¶¶289-290; Begault, 172-73, Fig. 5.12; §IV.E.3.

Additionally, Patentee has asserted in district court that limitation 1[c] requires only a WED that tracks an HPED that “cause[s] a game character to move.” Ex.1121 at 6. Under that interpretation, limitation 1[c] would have been obvious for the same reasons as limitations 1[a] and 1[b]. See §IV.E.2 (Pedrotti disclosed and rendered obvious HMD-tracked handheld controllers); §IV.E.3 (Pedrotti and Jang rendered obvious HPEDs moving binaural sound-producing virtual objects); Welch¶¶282-285.

5. 1[d]: Processor Processes Sound With HRTFs

Limitation 1[d] recites: “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.”

Jang disclosed, or at a minimum rendered obvious, processing, by a processor, sound with HRTFs to generate binaural sound that externally localizes to a user at SLPs. Jang taught that, “to give the sense of reality to the sound,” one can use “a localization technique capable of expressing the virtual location” of “a sound-generating object” and HRTFs. Jang, 1:42-51, 1:52-56. Jang further disclosed a “sound processing unit” comprising processors that “process sound” and identify “exact sound-generating location[s].” Jang, 7:38-63, 8:54-9:3. Also, as discussed, it would have been obvious that designated SLPs would be “in empty space in the zone above the physical floor.” §IV.E.3. Further, POSAs would have known that Pedrotti’s processor could and would manage sound, including as Jang described. Pedrotti recognized that “sight and sound” are “the senses most commonly used [] to create virtual reality” (Pedrotti, 1:18-20), and it was commonplace before June 2016 to use a processor to process sound with HRTFs to generate binaural sound. Welch ¶¶293-296.

Begault confirms this. Begault described HRTFs and ways to use HRTFs to process and generate binaural sound. Begault, 12-13, Fig. 1.8 (“signal processor” for “binaural output”), 41 (“The use of HRTF spectral shaping is typically featured as the key component of a 3-D sound system”), 99 (“the binaural HRTF is fundamental for a 3-D sound system”), ch. 2. POSAs would have known and been motivated to use such processing in a Pedrotti-Jang system for reasons discussed in Section IV.D, and because, by June 2016, it was well known that binaural sound was advantageous for virtual environments. Welch¶¶297-302.

In fact, Dr. Begault admitted that his own pre-2014 patents disclosed “generating binaural sound through digital signal processors processing HRTFs.” Begault Dep., 135:6-25. He also conceded that, “before 2014,” POSAs would have known “how to implement a system performing the function recited in” limitation 1[d] “by resorting to known audio DSP structures within the art and common industry programming techniques or software libraries.” *Id.* 196:12-197:18; Welch¶¶105-113.⁶

⁶ Even if limitation 1[d] were construed as a means-plus-function term, it would have been obvious over Begault because Begault described “convolution” processes using HRTFs (*e.g.*, Begault, 105-09), and because Dr. Begault has opined that “[c]onvolution is the main algorithm required to perform the claimed processes,”

6. 1[e]: Display a Virtual Image at the SLP

Pedrotti and Jang, or Pedrotti, Jang, and Begault render obvious limitation 1[e], which recites: “displaying, with the WED worn on the head of the user, a virtual image at the location of the SLP in empty space in the zone above the physical floor from where the binaural sound originates to the user.”

Pedrotti disclosed displaying virtual images with its HMD. §IV.E.2. And Jang disclosed outputting “audio, sound, and/or other sensory data” “to the user to represent the virtual environment,” and that its sound system “check[s] sound source information on other characters and other objects existing in [] virtual reality spaces” to “provide[] 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.” Jang, 6:17-20, 6:36-42, 7:24-32. Thus, POSAs would have known that when Pedrotti’s controller is used to move virtual objects, for example to position audio sources in a Pedrotti-Jang (or Pedrotti-Jang-Begault) system, *see* §IV.E.3, such a system would (or at a minimum obviously would) display virtual

while conceding that convolution was “well-known.” Ex.1128 ¶16; Begault Dep., 59:4-16 (admitting “many references” “in the 1990s” “discuss[ed] using convolution processes to process [HRTFs] with digital signal processors for binaural audio”).

images at the locations to which the virtual objects were moved and/or assigned (SLPs). Welch¶¶308-311.

For example, POSAs would have understood that if users designated locations for an announcer and a pep band in Jang’s virtual basketball court, images of the announcer and pep band could and would be displayed at their assigned locations. As another example, POSAs would have understood that if a user used an interface like those described in Begault to arrange sound sources—e.g., through icons representing sound sources, which are “virtual images” themselves—then corresponding virtual images of the arranged sound sources (e.g., a computer monitor) could and would be displayed in the virtual environment at their designated locations. Begault, 172-73, Fig. 5:12; Welch¶¶312-314. As Dr. Begault wrote in the Begault reference and confirmed in the district court action, “in virtual reality and multimedia applications, most sounds are somehow connected to visual events.” Begault, 95; Begault Dep., 244:16-245:12; *id.* 236:2-24.

Moreover, for reasons discussed, it would have been obvious that SLPs for binaural sound and their associated images could and would be “in empty space in the zone above the physical floor,” for example, in the user’s virtual environment gameplay space in Pedrotti’s zone, where no physical objects are located. §IV.E.3.

Additionally, Patentee has asserted in district court that limitation 1[e] requires only displaying a sound-generating character, at any location in a virtual

environment. Ex.1121, 9. Under that interpretation, limitation 1[e] would have been obvious for the same reasons as limitations 1[a] and 1[b]. *See* §IV.E.2 (Pedrotti’s HMD displays images); §IV.E.3 (Pedrotti and Jang render obvious displaying binaural sound-producing virtual objects); Welch¶¶303-308.

F. Dependent Claims 2-7

Claims 2-7 are unpatentable for the same reasons as claim 1 and as further explained below.

1. Claim 2

a. 2[a]: VR Character That Talks

Limitation 2[a] recites: “The method of claim 1, wherein the binaural sound is a voice of a virtual reality (VR) character that talks to the user while the user plays a VR game.”

Pedrotti’s system was designed to be used while a user is “playing a game within a virtual world.” Pedrotti, 11:48-52. And based on Pedrotti and Jang (and many other references), POSAs would have known that games in virtual environments could and would include VR characters that talk to users during gameplay. *See id.* 9:29-32 (user-controlled “character” is “conventional” in video games); Jang, 6:39-59, 7:14-37 (disclosing binaural sound processing that mixes visual elements of a virtual environment, “including a user’s avatar or character and other avatars, characters, objects, or features,” with related audio data—which POSAs would have known could and would include a character’s voice—before

outputting sensory elements to the user); Welch¶¶318-324 (collecting references disclosing speaking VR characters); Ross, 17:63-18:9 (“a character and/or avatar” “walks the user through a scene in virtual space and points things out,” similar to a “commentary track”).

b. 2[b]: Localized VR Character Voice

Limitation 2[b] recites: “and the voice externally localizes to the user at the VR character that is at the location of the SLP in empty space in the zone above the physical floor.”

For the same reasons it would have been obvious to externally localize other sounds to SLPs, it would have been obvious to externally localize a VR character’s voice to a VR character’s image (at an SLP). §§IV.E.3-IV.E.5. Such localization drives 3D audio and binaural sound and was routinely used to match sounds to associated visual elements. *Id.*; Welch¶¶325-326.

2. Claim 3

a. 3[a]: Tracked HPED Moves in an Arc

Limitation 3[a] recites: “The method of claim 1 further comprising: tracking, with the WED worn on the head of the user, the HPED held in the hand of the user as the HPED moves in a trajectory having a shape of an arc.”

Pedrotti disclosed an HMD-tracked handheld controller (§IV.E.2), and it would have been obvious that Pedrotti’s HMD-tracked controller could and would move in a trajectory having an arc shape. Pedrotti disclosed multiple virtual objects

that POSAs would have understood move in such a trajectory, e.g., swords, tennis rackets, and golf clubs. Pedrotti, 9:29-52, 16:33-42, Fig. 8; Welch¶¶327-329; Begault Dep., 195:12-16 (admitting that, before 2014, people could “point” and “gesture” with controllers in VR).

b. 3[b]: Sound Moves Along Arc

Limitation 3[b] recites: “processing, by the processor and with the HRTFs, the sound to generate SLPs of the binaural sound that moves through the empty space along the trajectory having the shape of the arc.”

Limitation 3[b]’s HRTF processing would have been obvious for the same reasons as limitation 1[d]’s. §IV.E.5. Additionally, it would have been obvious to use HRTFs to process binaural sound that moves through empty space in a virtual environment along an arc trajectory as a handheld controller moves in that trajectory. POSAs would have known and been motivated to keep visual elements moving in an arc together with associated sounds, for example, if Pedrotti’s sword (controlled by Pedrotti’s controller) sliced through another virtual object. §IV.E.3; Welch¶¶330-332.

c. 3[c]: Display Shows Arc

Limitation 3[c], which recites, “displaying, with the WED worn on the head of the user, virtual images that follow the trajectory having the shape of the arc that shows the user the trajectory of the SLPs of the binaural sound moving through the

empty space,” would have been obvious for the same reasons as limitations 3[a] and 3[b]. §§IV.F.2.a-IV.F.2.b. POSAs would have known that when a virtual image displayed by Pedrotti’s HMD moves in an arc with its associated sound—e.g., when a user sees an arcing virtual sword and hears it slicing through another virtual object—the sword would show the user the trajectory of associated binaural sound moving through the virtual environment’s empty space. Welch¶¶333-335.

3. Claim 4

a. 4[a]: Determine Conflict with Boundary

Limitation 4[a] recites: “The method of claim 1 further comprising: determining, with the WED worn on the head of the user, when a location of the user conflicts with a boundary of the zone.”

Pedrotti’s processor, which can be in the HMD, “determine[s] from the position of [a] handheld controller that the handheld controller is within a first preselected distance from [a] boundary” 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.” Pedrotti, 2:44-59, 3:54-58, 4:37-44, 12:35-13:11, 13:46-14:5, 15:4-39, 16:22-24, Figs. 11, 15. Pedrotti disclosed that “the preselected distance” triggering its warning “may vary by application” and users’ expected body movements. *Id.* 13:46-62. Also, Pedrotti

taught that if the user's head "goes beyond the boundary"—i.e., conflicts with the boundary—"the processor can cause the HMD to fade to black, and present, for example, only a warning message and/or a beacon or arrows directing the user to move in the direction of the boundary and the selected area." *Id.* 13:67-14:5. Thus, Pedrotti disclosed or at a minimum rendered obvious determining, with a WED worn on a user's head, when a location of the user conflicts with a boundary of a zone. Welch¶¶336-341.

b. 4[b]: Display Boundary Of Zone

Limitation 4[b] recites: "displaying, with the WED, the boundary of the zone to alert the user that the location of the user conflicts with the boundary of the zone."

Pedrotti's HMD can (or obviously can) display "a visual warning such as a grid or virtual fence" to "provid[e] a warning that the user is about to move out of the selected area" if the user approaches, crosses, or "conflicts with" a boundary. §IV.F.3.a; Welch¶¶342-344, 132-144 (discussing additional prior art systems that alerted users of boundary conflicts); VR Book, Fig. 8.13; Begault Dep., 210:20-211:12.

4. Claim 5

a. 5[a]: Display Zone as Lines

Limitation 5[a], which recites, "The method of claim 1 further comprising: displaying, with the WED worn on the head of the user, a virtual image of the zone as lines that extends from the physical floor and around the user," was disclosed or

rendered obvious by Pedrotti for reasons discussed in Sections IV.E.2 and IV.F.3.b. Pedrotti, 12:63-66 (HMD generates a “visual warning” “in the form of a grid of lines or a ‘virtual fence’”), Fig. 11; §IV.A; Welch¶¶345-346.

b. 5[b]: Customized Zone

Limitation 5[b] recites: “wherein the zone has a customized shape drawn by user with the HPED, and the WED stores coordinate locations of the customized shape.”

Pedrotti taught that its zone can be “a customized shape drawn by [a] user with [an] HPED” because a user of Pedrotti’s system can define the boundary for Pedrotti’s zone by “walk[ing] around a perimeter chosen by the user.” Pedrotti, 14:56-62; §§IV.A, IV.E.2; Welch¶347. That boundary can be “an irregularly shaped area”—i.e., customized—as Pedrotti’s Figure 14 shows. Pedrotti, 14:56-62, Fig. 14; Welch¶347. Further, POSAs would have known that Pedrotti’s system stores coordinate locations of a zone of a customized shape because the system uses the boundaries to determine when to display its virtual fence. Pedrotti, 15:30-39, Fig. 15; Welch¶348. POSAs also would have known that such information could and would be stored in Pedrotti’s HMD. Welch¶349. Such storage was known, as Jang shows. Jang, Fig. 1A (“storage unit” 102 in “virtual reality apparatus” 110); Ross, Figs. 1-2 (“electronic storage 30” in HMD); Welch¶349.

5. Claim 6

a. 6[a]: Display a Virtual Monitor

Limitation 6[a] recites: “The method of claim 1 further comprising: displaying, with the WED, a virtual monitor in a field of view (FOV) of the user.”

Jang taught the display of “visual sensory elements” in VR, including in the “visual perspective of the character,” i.e., the field of view (FOV) of the user. Jang, 4:20-24, 6:15-17, 6:55-59. Jang also depicted a monitor in its virtual conference room. *Id.* Figs. 5-6. Accordingly, Jang disclosed and rendered obvious limitation 6[a]. Welch¶¶350-351. Further, POSAs would have been motivated to use a virtual monitor in a Pedrotti-Jang system because virtual monitors were known to be useful tools for providing information to users in virtual environments. *Id.*¶¶353-357. For example, in the district court action, Dr. Begault testified that, even in the late 1980s, POSAs were already using systems with “virtual menu[s] floating in the sky that you would see through [an] HMD,” which could be used to “select” and “interact with virtual objects.” Begault Dep., 42:2-43:6, 43:19-44:20, 46:12-47:23; Welch¶¶353-357.

Begault also rendered limitation 6[a] obvious, disclosing a “computer monitor” icon in an interface for controlling a 3D sound system. Begault, Fig. 5.12. That icon is itself a “virtual monitor,” and for reasons discussed in Section IV.E.6 and immediately above, it also would have been obvious to display a virtual monitor

at the position in the virtual environment that Begault's GUI designates for the monitor's 3D sound. Welch¶352.

b. 6[b]: Sound Comes From Virtual Monitor

Limitation 6[b] recites: "processing, by the processor, the sound with the HRTFs to generate the binaural sound that originates from the virtual monitor." For the same reasons it would have been obvious to use a processor to process sound with HRTFs to generate binaural sound originating from other sound-generating VR objects, it would have been obvious to process sound with HRTFs to generate binaural sound from a virtual monitor. §§IV.E.5, IV.F.2.b, IV.F.2.b; Welch¶¶358-359; *see also* Begault, 159-60 (sounds "spatialized using 3-D audio techniques," including through "HRTF filtering"—i.e., binaural sounds—used for "selecting items," e.g., "click" and "latch" sounds).

c. 6[c]: Sound Maintained At Virtual Monitor

Limitation 6[c] recites: "tracking, with the WED, head movements of the user to maintain the binaural sound originating from the virtual monitor as the head of the user moves."

Pedrotti's HMD, with its processor, tracks users' head movements. Pedrotti, 4:49-52 ("Attached to or incorporated in the HMD 106 is a tracker 108, which can be used to determine the position and orientation of the headset 104, and thus of the head of user 102."), 12:31-39 ("processor knows where the user's head and hands

are located”); 16:22-24. And Jang disclosed, or at a minimum rendered obvious, the spatialization of binaural sound to particular SLPs and sound-generating VR objects. §IV.E.5. Consequently, POSAs implementing the teachings of Pedrotti and Jang would have known and been motivated to use Pedrotti’s head tracking to ensure accurate localization of generated binaural sound, including for sound from a virtual monitor, and when the head of a user moves. Welch¶¶360-362.

It was well known before 2016 that head movements should be tracked to maintain proper locations for binaural sound, including when listeners move. For example, Begault disclosed that if a sound source “should stay in a single location in virtual space”—which would apply to a virtual monitor set at a particular location—“then its location relative to the listener’s head position will also need to be synthesized and updated in real-time.” Begault, 6. And Begault taught that “trackers [] allow updating the position of the virtual sound source in relation to the position of the head” so that “virtual sound images [can] remain fixed in virtual space independent of where one’s head moves.” Begault, 12, 99, 132-34 (“3D audio” system “compensate[s] for the relative position of source and sensor” so sound “remains fixed in space independent of head movement”), Figs. 4.37-4.38.

Thus, it would have been obvious that, in a Pedrotti-Jang system or a Pedrotti-Jang-Begault system, Pedrotti’s head tracking could and would be used to maintain binaural sound originating from a virtual monitor as the head of a user moves, as

claimed. Welch¶¶360-365; *see also* Begault Dep., 250:2-9 (admitting systems in the 1980s used this technique).

6. Claim 7: Cylindrical Zone

Claim 7, which recites, “The method of claim 1, wherein the zone has a shape of a cylinder that extends from the physical floor and around the user, and the WED displays the cylinder to the user,” would have been obvious for the same reasons as limitations 4[b] and 5[b]. §§IV.F.3.b, IV.F.4.b. POSAs would have understood that, if a user defined a circular boundary for Pedrotti’s zone—for example, if that was a suitable or advantageous shape for the user’s VR gameplay area, including based on surrounding obstacles—then the zone, with its “virtual fence,” would have (or at a minimum obviously would have) the shape of a cylinder extending from the physical floor and around the user. Welch¶367. Moreover, Pedrotti depicted circular boundaries and disclosed displaying a “cylindrical projection” of its “virtual fence.” Pedrotti, 13:12-33, Figs. 12-13; Welch¶¶366-368.

G. Claim 8⁷

1. 8[pre]: Method Executed by Electronic Devices

Claim 8’s preamble would have been obvious for the same reasons as claim 1’s. §IV.E.1; Welch¶370.

⁷ The recitations of claims 1 and 8 are nearly identical. Where claim 8’s language differs, it is addressed.

2. 8[a]: WED Tracking a HPED Defining a Zone

Limitation 8[a] would have been obvious for the same reasons as limitation 1[a]. §IV.E.2; Welch¶¶371-372.

3. 8[b]: Designating an SLP

Limitation 8[b] would have been obvious for the same reasons as limitation 1[b]. §IV.E.3; Welch¶373.

Additionally, POSAs would have known it was common to use handheld controllers to select, move, and control virtual objects by pointing at them. *See* VR Book, 327 (“Pointing Pattern” is “fundamental and often-used... for selection”); Ross, 22:17-29 (“using a controller (e.g., a pointer)” “to control” VR content). Thus, it would have been obvious to use Pedrotti’s controller (HPED) to designate an SLP “where the HPED is pointed.” Welch¶¶374-375.

4. 8[c]: Tracked HPED Provides Location of SLP

Limitation 8[c] would have been obvious for the same reasons as limitations 1[c] and 8[b]. §§IV.E.4 and IV.G.3; Welch¶376.

Additionally, tracking “where the HPED is pointed” would have been obvious because, as noted, “[p]ointing” is a “fundamental” “pattern[] for selection.” VR Book, 327; Welch¶¶77-86, 377.

5. 8[d]: Processor Processes Sound with HRTFs

Limitation 8[d] would have been obvious for the same reasons as limitation 1[d]. §IV.E.5; Welch¶¶378-380.

6. 8[e]: Display a Virtual Image at the SLP

Limitation 8[e] would have been obvious for the same reasons as limitation 1[e]. §IV.E.6; Welch¶381.

H. Dependent Claims 9-13

Claims 9-13 are unpatentable for the same reasons as claim 8 and as further explained below.

1. Claim 9: VR Character Voice

Claim 9 is substantively the same as claim 2, and obvious for the same reasons. §IV.F.1 (claim 2); Welch¶385-386.

2. Claim 10: VR Game with Zone Lines

Claim 10 recites: “The method of claim 8 further comprising: displaying, with the WED, a boundary of the zone with virtual lines to alert the user when the user conflicts with the boundary of the zone while the user plays a virtual reality (VR) game.”

Pedrotti’s HMD (WED) displays a boundary of Pedrotti’s zone with virtual lines to alert the user when the user conflicts with the boundary of the zone—Pedrotti’s “visual warning in the form of grid lines or a virtual fence.” Pedrotti, 15:46-55; §IV.F.3 (claim 4); §IV.F.4.a (limitation 5[a]). Pedrotti’s system was designed to be used while a user is “playing a game within a virtual world,” i.e., a VR game. Pedrotti, 11:48-52; §IV.F.1 (claim 2); Welch¶387.

3. Claim 11: Display Customized Zone

Claim 11, which recites, “The method of claim 8 further comprising: displaying the zone as a customized three-dimensional (3D) shape drawn by the user with the HPED held in the hand of the user,” would have been obvious for the same reasons as limitations 1[a] and 5[b]. §§IV.E.1, IV.F.4.b; Welch¶388.

4. Claim 12: HPED Moves the SLP

Claim 12 recites: “The method of claim 8 further comprising: tracking, with the WED, a location where the HPED is pointed as the HPED moves the SLP and the virtual image from one location where the HPED is pointed to another location where the HPED is pointed.”

Pedrotti disclosed HMD-tracked handheld controllers (HPED), and for reasons discussed in the context of limitations 8[b] and 8[c], it would have been obvious to track where Pedrotti’s controllers were pointed. This would include when Pedrotti’s controllers were used to move virtual objects, including SLPs and virtual images, which Pedrotti, Jang, and Begault render obvious, and which was routine before June 2016, as Dr. Begault admitted. §§IV.E.2-IV.E.4, IV.F.2, IV.G.3-IV.G.4; Welch¶389; Begault Dep., 195:12-196:10.

5. Claim 13: DSP and HRTFs in Cache

Claim 13, which recites, “The method of claim 8 further comprising: improving performance of the processor processing the sound by storing the HRTFs in a cache memory in the WED, wherein the processor is a digital signal processor

(DSP) located in the WED,” would have been obvious for the same reasons as limitations 1[d], 5[b], and 8[d]. §§IV.E.5 and IV.G.5 (processing sound with HRTFs, including with DSPs, was well known, as Dr. Begault conceded), §IV.F.4.b (HMD storage was known).

Additionally, Begault disclosed multiple examples using DSPs for spatializing sound sources and explained that “[w]ithin a virtual reality or multimedia application, 3-D sound processing is almost always best accomplished digitally, using audio DSP chips.” Begault, 100-101. Begault thus shows that POSAs would have known and had reason to use DSPs for sound processing in a Pedrotti-Jang system. Welch¶¶390-391. POSAs would have understood that DSPs are fast, excel at signal processing tasks like HRTF processing, are reconfigurable and flexible, and are appropriately sized for use in systems like Pedrotti’s and Jang’s. *Id.*¶¶392-397.

Further, Dr. Begault conceded that storing HRTFs in memory, including in cache memory, was known. Begault Dep., 206:11-16. And in view of at least Pedrotti’s disclosure of locating a processor “in the HMD” (Pedrotti, 16:22-24), and before June 2016, POSAs would have known and been motivated to store HRTFs in cache in Pedrotti’s HMD to achieve processor performance improvements, e.g., through more rapid cache accesses. Welch¶397 (collecting references storing

HRTFs in cache and explaining that POSAs knew to leverage cache locality for improved processor performance).

I. Claim 14⁸

1. 14[pre]: Electronic System

The preamble of claim 14 recites: “An electronic system, comprising.” Pedrotti and Jang disclose electronic systems. §§IV.A, IV.B, IV.E.1, IV.G.1; Welch¶399.

2. 14[a]: PED Defines Zone and Designates An SLP

Limitation 14[a] would have been obvious for the same reasons as limitations 1[a]-1[b] and 8[a]-8[b], and because POSAs would have known a user stands on a physical floor. §§IV.E.2-IV.E.3, IV.G.2-IV.G.3; Welch¶¶400-402 (Pedrotti’s controller also is the “PED” in claim 14).

3. 14[b]: WED Tracks PED to Determine Boundary

Limitation 14[b] would have been obvious for the same reasons as limitations 1[a] and 8[a]. §§IV.E.2, IV.G.2; Welch¶403.

⁸ The recitations of claims 1, 8 and 14 are nearly identical. Where claim 14’s language differs, it is addressed.

4. 14[c]: Processor Processes Sound with HRTFs

Limitation 14[c] would have been obvious for the same reasons as limitations 1[d] and 8[d]. §§IV.E.5, IV.G.5; Welch¶404; Begault Dep., 197:20-198:12.

5. 14[d]: Display Virtual Images at the SLP and the Zone Boundary

Limitation 14[d], including its requirement that the virtual image showing the boundary of the zone be “3D,” would have been obvious for the same reasons as limitations 1[e], 4[b], 5[a], and 8[e]. §§IV.E.6, IV.F.3.b, IV.F.4.a, IV.G.6; Welch¶405. POSAs would have known that Pedrotti’s virtual fence was (or at a minimum obviously could be) a “3D” virtual image showing Pedrotti’s zone’s boundary. Welch¶406. Pedrotti further taught that virtual images displayed to show zone boundaries can vary, as known to and desired by developers, for example to match “the particular virtual world being displayed.” Pedrotti, 12:60-13:11. And chaperone systems for virtual environments displaying “3D” virtual images to alert users that locations conflicted with boundaries were known. Welch¶¶140-142.

J. Dependent Claims 15-20

Claims 15-20 are unpatentable for the same reasons as claim 14 and as further explained below.

1. Claim 15: Customized Zone

Claim 15, which recites, “The electronic system of claim 14, wherein the 3D zone has a customized size and shape defined by movement of the PED while held in a hand of the user,” would have been obvious for the same reasons as limitation 5[b]. §IV.F.4.b; Welch¶¶410-411.

2. Claim 16

a. 16[a]: Determine PED is at Boundary

Limitation 16[a], which recites, “The electronic system of claim 14, wherein the WED tracks the PED to determine when the PED is at the boundary of the 3D zone,” would have been obvious for the same reasons as limitation 4[a]. §IV.F.3.a; Welch¶¶412-415.

b. 16[b]: Display Boundary of Zone

Limitation 16[b], which recites, “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,” would have been obvious for the same reasons as limitation 4[b]. §IV.F.3.b. Further, Pedrotti’s virtual fence (or other 3D image showing the boundary) is displayed “automatically” (i.e., without user input), and POSAs would have known it could (or obviously could) be so displayed when the processor in Pedrotti’s HMD determines that a controller (PED) is “at” Pedrotti’s boundary. §IV.F.3.b (Pedrotti discloses, or at a minimum renders obvious, display

of a zone when a user's location "conflicts with" (or is "at") a boundary); Welch¶¶416-417.

3. Claim 17

a. 17[a]: Determine User is at Boundary

Limitation 17[a], which recites, "The electronic system of claim 14, wherein the WED tracks the user to determine when the user is at the boundary of the 3D zone," would have been obvious for the same reasons as limitations 1[c] and 4[a]. §§IV.E.4, IV.F.3.a; Pedrotti, 12:35-39 ("the processor knows where the user's head and hands are located," so "the processor can also determine when the user's head"—i.e., the user—"and/or hand approaches the boundary."); Welch¶¶418.

b. 17[b]: Display Boundary of Zone

Limitation 17[b], which recites, "the WED automatically displays the 3D virtual image that shows the boundary of the 3D zone to alert the user that the user is at the boundary of the 3D zone," would have been obvious for the same reasons as limitations 4[b], 16[b], and 17[a]. §§IV.F.3.b, IV.J.2.b, IV.J.3.a; Welch¶¶419-420.

4. Claim 18

a. 18[a]: Determine Location of User

Limitation 18[a], which recites, "The electronic system of claim 14, wherein the WED determines a location of the user," would have been obvious for the same

reasons as limitations 4[a] and 17[a]. §§IV.F.3.b, IV.J.3.a; Welch¶¶421-422; Pedrotti, 12:35-39 (“processor knows where the user’s head” is).

b. 18[b]: Store Zone for Location

Limitation 18[b], which recites “stores the 3D zone for the location,” would have been obvious for the same reasons as limitation 5[b]. §IV.F.4.b (discussing Pedrotti’ storage of customized zones); Welch¶¶423-426.

c. 18[c]: Display Boundary if User is There

Limitation 18[c], which recites, “displays the 3D virtual image that shows the boundary of the 3D zone in response to determining that the user is at the location,” would have been obvious for the same reasons as limitations 4[b] and 17[a]-17[b]. §§IV.F.3.b, IV.J.3.a-IV.J.3.b.

Additionally, this limitation would have been obvious based on Pedrotti’s disclosures relating to setting boundaries. As a user “moves around [a] chosen perimeter” (Pedrotti, 14:62-65), the user is at location(s) corresponding to the zone being stored. POSAs would have known and been motivated to display a 3D virtual image showing the chosen boundary for the 3D zone so the user receives feedback on the boundary and knows it is being defined as desired. This display could and would occur (or at a minimum would obviously occur) in response to a determination that the user is at a location for the zone—as discussed, Pedrotti’s processor tracks the user, tracks the user’s HPEDs, defines the user’s boundary based

on “sampling points” from its tracking, and makes determinations of when a user “comes within a preselected distance of the boundary.” Welch¶¶427-431. Consequently, an obvious and straightforward application of Pedrotti’s comparative processing capabilities and display functions would involve determining a user’s location during creation of a boundary for a zone that is stored, comparing that location to the boundary, and displaying a virtual image of the boundary to the user to ensure accurate boundary and zone setup. *Id.*¶¶428-429; Ross, 6:5-27, 22:23-23:21 (describing user configuration of boundaries and use of a “[c]ontent creation preview” that allows users to “continue to make changes” to those boundaries).

5. Claim 19

a. 19[a]: WED Has Light-Tracking Sensors That Track PED Defining Zone

Limitation 19[a] recites: “The electronic system of claim 14, wherein the WED includes one or more sensors that track a light source in the PED to determine a location of the PED as the PED moves to define the boundary of the 3D zone.” Pedrotti disclosed, or at a minimum rendered obvious, limitation 19[a].

Pedrotti disclosed that its trackers, including the trackers in its handheld controllers, may be “light-emitting trackers which can be seen by, and therefore provide position and orientation information to, a camera mounted on [a] base station or elsewhere,” i.e., the claimed sensor. Pedrotti, 5:8-24. POSAs thus would have known and been motivated to use an HMD, e.g., with sensor cameras, to track

light-emitting trackers in Pedrotti's controllers, including while the controllers move to define the zone around the user. Welch¶¶432-436; §IV.I.2. The technique of using sensors on HMDs to track light sources, such as infrared light, emitted from PEDs to determine location was well known and widely used due to accuracy advantages. Welch¶¶87-104, 435; VR Book, 315 ("Hand-held tracked devices typically use inertial, electromagnetic, ultrasonic, or optical (camera) technologies.").

b. 19[b]: Display a Virtual Monitor

Limitation 19[b], which recites, "the WED displays a virtual monitor at the SLP in empty space inside the 3D zone," would have been obvious for the same reasons as limitations 6[a] and 6[b]. §§IV.F.5.a-IV.F.5.b; Welch¶437.

c. 19[c]: Sound Maintained at Virtual Monitor

Limitation 19[c], which recites, "the binaural sound continues originates to the user at the virtual monitor as the head of the user rotates to different orientations with respect to the virtual monitor," would have been obvious for the same reasons as limitations 6[b] and 6[c]. §§IV.F.5.b-IV.F.5.c; Welch¶438.

6. Claim 20: Display Zone as Lines

Claim 20, which recites, "The electronic system of claim 14, wherein the WED displays the 3D virtual image that shows the boundary of the 3D zone as lines to enable the user to determine the boundary of the 3D zone," would have been obvious for the same reasons as limitations 4[b] and 5[a] and claim 10. §§IV.F.3,

IV.F.4.a, IV.H.2; Welch¶439. POSAs would have known that a user could determine a boundary when it is displayed. Welch¶¶140-142, 440.

V. Ground 2: Claims 1-20 are Unpatentable Over McCulloch, Pedrotti, and Flaks

Challenged claims 1-20 are unpatentable over McCulloch in view of Pedrotti, and further in view of Flaks, for the reasons discussed below.

A. Overview of McCulloch

McCulloch, issued on May 26, 2015, is § 102(a) prior art and was not considered during prosecution.

McCulloch disclosed a system for controlling virtual objects displayed by an “augmented reality display” comprising an HMD, control circuitry, and “controller device[s].” McCulloch, 1:46-48, 4:25-55, 6:55-7:22, 8:1-39, Figs. 1B, 2A, 5. McCulloch’s HMD receives user input “requesting an action to be performed by the virtual object” through controllers, “appl[ies] the user input,” and then “display[s] the action.” *Id.* 1:59-66, 11:42-46.

The HMD tracks its position and orientation, “virtual objects” in the field of view, and the handheld controllers for controlling those objects. *Id.* 4:14-31, 7:24-67, 8:17-9:16, 11:56-12:17, 12:41-48, 15:30-47, 29:4-43, Figs. 4A, 8B, 8D. McCulloch further taught that users “identify[] boundaries for a playspace in which virtual objects can be positioned.” *Id.* 20:11-13.

McCulloch's HMD has an image and audio processing engine that renders virtual scenes, stores virtual object data, and generates 3D audio. *Id.* 13:56-14:67, 21:21-38, 22:66-23:4, Fig. 4A, cl. 8. McCulloch taught that each object is associated with audio projected from its "3D space position" generated through HRTF processing (*id.* 26:7-19)—i.e., binaural sound from SLPs—including as described in U.S. Patent Application No. 12/903,610, which McCulloch incorporated by reference. *Id.* 21:21-38. That application issued as U.S. Patent No. 8,767,968, the Flaks reference. Flaks (Ex.1009), Cover; Welch¶¶187-199.

B. Overview of Flaks

Flaks, issued in July 2014, is § 102(a) prior art and was not considered during prosecution. Flaks disclosed techniques "for providing 3D audio," including applying HRTFs to generate "3D audio signal[s]," i.e., binaural sound. Flaks, Abstract, 9:4-10:4, 11:44-13:16, 13:55-14:4, Figs. 5A, 7, 8, 10; Welch¶¶200-208.

C. Motivations to Combine

McCulloch incorporates, and thus includes as part of its own disclosures, Flaks's "3D audio engine." McCulloch, 21:21-38. Further, POSAs would have known to combine McCulloch's system with Flaks' 3D audio engine because McCulloch says to do so, and to enhance the VR immersive experience using 3D audio. *Id.*; §V.A; Welch¶¶455-456.

Additionally, POSAs would have been motivated to combine McCulloch's system (including Flaks's 3D audio engine) with Pedrotti's method for assisting a user in remaining within a selected area. McCulloch taught "identifying boundaries for a playspace" (McCulloch, 20:11-13), and POSAs would have recognized that Pedrotti describes an advantageous method for defining boundaries for virtual environments, including to protect users. §IV.A; Welch¶¶443-454.

In AR and VR environments, immersivity is key, and users risk personal injury and property damage due to collisions and tripping hazards. For example, a user may be following a virtual helicopter flying overhead, as McCulloch describes, and accidentally trip over a sofa. Or if a user is attacking a virtual monster standing in front of (and occluding) a bookshelf, the user may hit the bookshelf. Pedrotti encourages POSAs to use its system given these known risks, including with systems that obscure only "portion of the user's field of vision of the physical world," like McCulloch's. Pedrotti, 16:14-19. Pedrotti's methods help users stay within boundaries and avoid such collisions, without disrupting immersive experiences. Welch¶¶446-452; §IV.A; Pedrotti, 11:66-12:3; McCulloch, 26:35-48, 20:28-29, 23:39-51.

McCulloch (including with Flaks) and Pedrotti also are analogous art. Both are directed to systems and methods for providing immersive, interactive virtual

experiences and use motion-tracked HMDs and controllers. §§IV.A, V.A; Welch¶¶444-445.

Furthermore, POSAs combining the teachings of McCulloch (including with Flaks) with Pedrotti's methods would have had a reasonable expectation of success. These references disclosed hardware that was well known before June 2016, such as HMDs, controllers, and processors, and common methods of using such hardware, e.g., to set boundaries and process sound with HRTFs. §§IV.A, V.A-V.B. McCulloch's HMD already had the capability to capture and store playspace boundaries. McCulloch, 20:11-13. It also had a computing platform for running AR applications and displaying virtual objects, and could thus display a virtual fence as taught by Pedrotti. To POSAs, combining the teachings of McCulloch, Flaks, and Pedrotti to implement Pedrotti's "safe area" system would have been obvious to try and well within common sense, and would have been routine, requiring no more than combining known elements with known functions, to improve similar devices in known ways. Welch¶¶453-454.

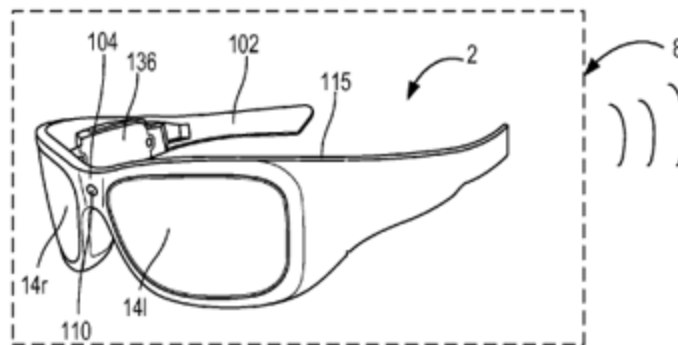
D. Claim 1

1. 1[pre]: A Method Executed by Electronic Devices⁹

McCulloch disclosed methods executed by electronic devices, including an HMD and controllers. McCulloch, 4:49-55, 6:55-61, Figs. 1A-1B; Welch¶¶457-458. So did Pedrotti. §IV.E.1; Welch¶459.

2. 1[a]: WED Tracking a HPED Defining a Zone

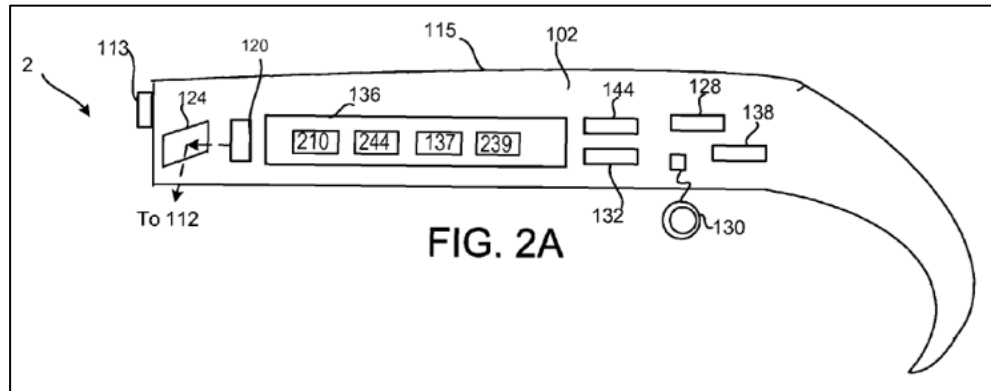
McCulloch and Pedrotti render limitation 1[a] obvious. McCulloch disclosed a “display device system 8” comprising a “head mounted display device 2” (WED) worn on a user’s head:



McCulloch, Fig. 1B (excerpted), 4:49-55, 8:1-46; *see also* '737 patent, 41:65-67 (“electronic glasses” and HMDs listed as WEDs).

⁹ The attached Claims Appendix and Ground 1 present claim recitations in full.

McCulloch's HMD (WED) tracks handheld controllers (HPEDs). The HMD has "[c]ontrol circuitry 136" comprising a "processing unit 210" including "one or more processors":



McCulloch, Fig. 2A, 8:1-16. And the "computing environment" for the "display device system 8," which includes the HMD as shown above, comprises an "image and audio processing engine 191." *Id.* Fig. 4A, 13:52-18:7 (describing "computing environment 54"). That engine receives inertial and positional data from McCulloch's "handheld IMU controller[s]," i.e., it tracks them (or at a minimum obviously tracks). *Id.* 4:25-31, 28:63-66, 29:4-63 ("Inertial motion sensors" in handheld controllers "identify parameters like speed, acceleration and direction of motion," "which is sent as data to the display device system 8"), 24:28-35, Figs. 8B, 8D. McCulloch further taught that its HMD tracks the controllers relative to the HMD and surrounding environment, as the HMD tracks its own position and uses image and depth data to track objects, e.g., controllers, in front of the user. *Id.* 7:34-59, 8:17-30, 12:18-21, 22:4-8, 28:5-11; Welch ¶¶460-471. Moreover, it would have

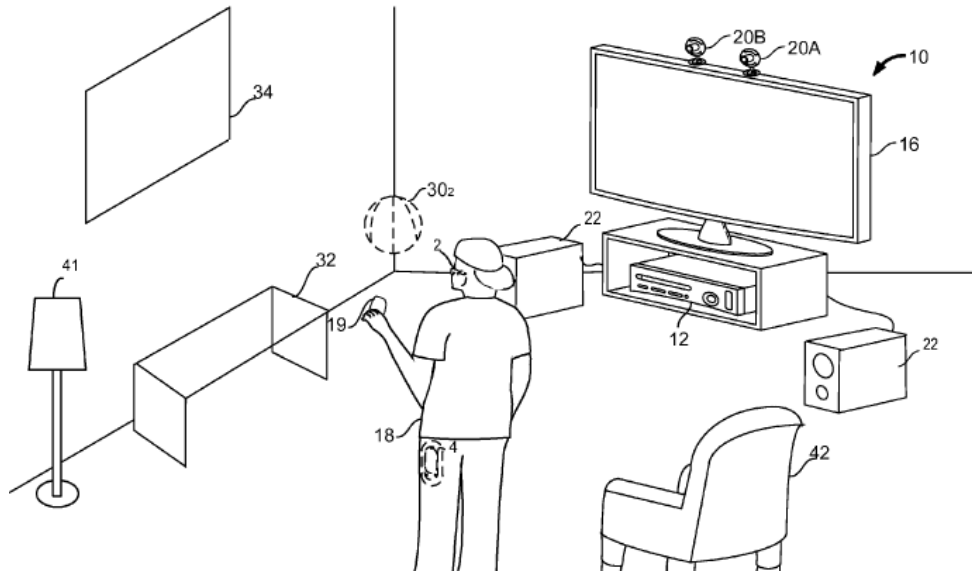
been obvious for McCulloch’s HMD to track controllers, particularly for the gaming applications McCulloch describes, because that functionality was common before June 2016. Welch¶¶87-104, 472; VR Book, 315 (discussing “[h]and-held tracked devices” using “inertial, electromagnetic, ultrasonic, [and] optical (camera) technologies”).

Additionally, implementing McCulloch’s system with Pedrotti’s “safe area” zone would render limitation 1[a] obvious, including the requisite HPED movement defining a 3D zone, in view of the Pedrotti disclosures discussed for limitation 1[a] in Ground 1. §§IV.E.2, V.C; Welch¶¶473-474.

3. 1[b]: Designating an SLP

As discussed in Ground 1, Patentee contends in district court that limitation 1[b] requires only “a game character” being “moved by direction of [an] HPED.” §IV.E.3. McCulloch—like Pedrotti, Jang, and other AR and VR references (*id.*; Welch¶¶241, 243-244, 251-253, 475-476)—shows that limitation 1[b] would have been obvious under this interpretation.

McCulloch disclosed multiple examples of handheld controllers moving virtual objects. McCulloch, 12:49-13:51, 25:6-50, 29:4-17, Figs. 3A-3E, 8A-8D. For example, in Figure 8B, McCulloch depicts upward movement of “real controller device 19,” which “translate[s] into an up action” of a virtual basketball (30₂):



Id. Fig. 8B, 29:12-16. McCulloch also disclosed that sound for its virtual objects—e.g., the basketball smashing the television, or helicopters crashing into walls—should be produced “as if coming from the direction of the virtual object.” *Id.* 21:21-38, 14:53-67, 24:67-26:34 (processes for controlling virtual objects include “play[ing] audio for the virtual object projected from a 3D space position of the virtual object”), 26:7-19 (helicopter), 29:3-30:3 (basketball), Figs. 5, 8A-8D.

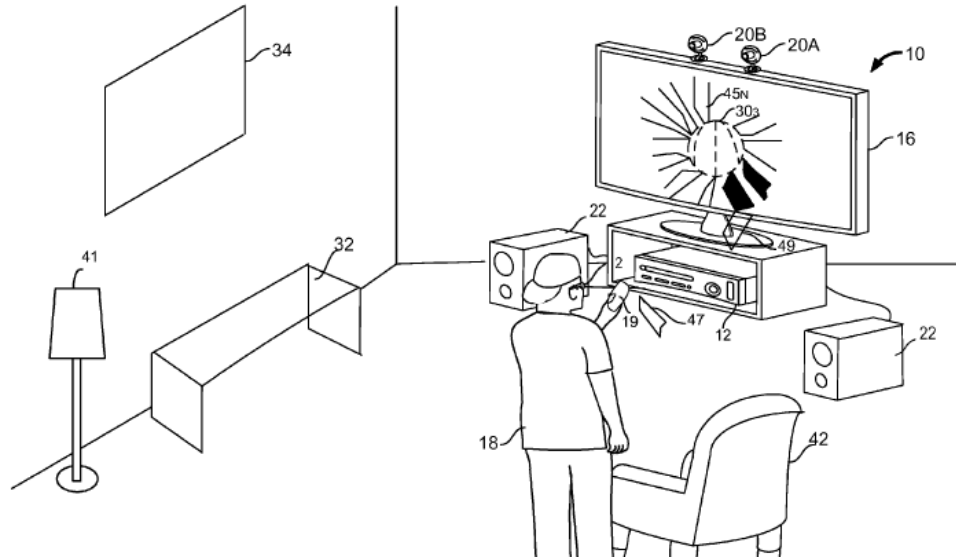
Additionally, McCulloch incorporates Flaks’s positional 3D audio engine (*id.* 21:29-34), which processes sound with HRTFs to “localize a sound as coming from a virtual sound source,” i.e., to generate binaural sound for McCulloch’s HPED-controlled virtual objects at those objects’ locations (SLPs). Flaks, 1:44-46, 1:62-64 (“realistic 3D audio”), 13:55-14:4; Welch¶¶477-483 (POSAs would have known that Flaks’s audio engine, i.e., McCulloch’s audio engine, uses HRTFs and “binaural cues” (Flaks, 1:9-11) to produce “binaural sound” at SLPs).

POSAs further would have known that locations from which sounds for McCulloch's virtual objects are perceived to originate (SLPs) are, or at a minimum obviously would be, in "empty space in the zone above the physical floor." For example, as shown in Figure 8B (reproduced above), McCulloch's virtual basketball is in empty space above a physical floor. The basketball is in McCulloch's "playspace" and would be in Pedrotti's zone in an implementation incorporating Pedrotti's teachings with McCulloch's, for reasons discussed in Ground 1. McCulloch, Fig. 8B; 29:4-17 (actions applied to "basketball virtual object 30₂"); §IV.E.3; Welch¶484. Other virtual images and associated binaural sounds, e.g., McCulloch's whirring helicopter, could and would be similarly situated. Welch¶478.

4. 1[c]: Tracked HPED Provides Location of SLP

McCulloch's HMD-tracked handheld controllers (HPEDs) move virtual objects and the locations for those objects' sounds (SLPs). §§V.D.2-V.D.3. Thus, POSAs would have known that McCulloch's controllers provide the HMD locations of SLPs in empty space and above a physical floor. Welch¶¶485-487.

Continuing with McCulloch's basketball example, Figure 8D depicts "the virtual basketball 30₃ collid[ing] with the display of [a] television" because the user "moved the handheld IMU device with such an intensity in the direction of the television 16":



McCulloch, Fig. 8D, 29:36-30:30, Figs. 8B-8C. This collision emits a crash sound from where the basketball hits the television, i.e., a binaural sound. *Id.* 21:34-38. And POSAs would have understood that for this sound to be localized to that location (SLP), McCulloch's HMD would have to (or would obviously) receive the collision's location from the HMD-tracked controller—i.e., the HPED would provide the WED the location of the SLP. Welch¶¶488-490. Additionally, for reasons discussed, SLPs in a McCulloch-Pedrotti (or McCulloch-Flaks-Pedrotti) implementation would be, or at a minimum obviously would be, in empty space in a zone above a physical floor. *Id.*¶491; §V.D.3.

5. 1[d]: Processor Processes Sound with HRTFs

McCulloch—via its incorporation of Flaks or in view of Flaks—disclosed, or at a minimum rendered obvious, limitation 1[d].

McCulloch's HMD includes a 3D audio engine for producing audio "projected from a 3D space position of the virtual object," i.e., binaural sound, and McCulloch incorporated Flaks for implementation details. McCulloch, 13:52-14:5, 14:59-64, 21:21-38, 25:60-26:19, Fig. 4A. Those details include Flaks's disclosure that 3D audio, i.e., binaural sound, is generated by processing HRTFs as claimed. Flaks, 2:6-20 (processor applies HRTFs to provide 3D audio); Welch¶¶492-497 (Flaks's audio engine uses HRTFs and "binaural cues" (Flaks, 1:9-11) to produce "binaural sound" at SLPs); *see also* Welch¶¶105-112, 498 (POSAs knew to process HRTFs with a processor to generate binaural sound); §IV.E.5; Begault Dep., 196:12-197:18 (effectively conceding limitation 1[d] was known).

Additionally, as noted, SLPs in a McCulloch-Pedrotti (or McCulloch-Flaks-Pedrotti) implementation would be, or at a minimum obviously would be, in empty space in a zone above a physical floor. §V.D.3; Welch¶499.

6. 1[e]: Display a Virtual Image at the SLP

McCulloch and Pedrotti both disclosed HMDs that display virtual images. McCulloch, Fig. 8B, 8:40-46, 16:49-65, 13:52-14:5, Fig. 4A; Pedrotti, Abstract; §IV.E.6. And, as discussed, McCulloch discloses, or at a minimum renders obvious, displaying virtual images, e.g., a basketball or a helicopter, at the locations for the images' binaural sounds (SLPs), e.g., where the basketball smashes a television or where helicopters crash into walls, including in empty space in a zone above a

physical floor. §§V.D.3-V.D.5 (limitations 1[b]-1[d]); Flaks, 4:10-20 (“virtual sound source 29a c[an] be an object being displayed on [a] display”); Welch¶¶500-505.

E. Dependent Claims 2-7

Claims 2-7 are unpatentable for the same reasons as claim 1 and as further explained below.

1. Claim 2

a. 2[a]: VR Character That Talks

McCulloch would have rendered limitation 2[a] obvious. POSAs would have known that McCulloch’s binaural sounds could and would be the voice of a VR character that talks to a user in a VR game.

McCulloch taught that its inventions are useful for controlling virtual objects for virtual games. McCulloch, Title, 4:25-31 (controllers “associated with gaming consoles or game applications”), 6:12-33 (“virtual objects” for “a game application”), 20:60-63 (incorporating Mount 350 (Ex.1027) by reference); Mount 350, [0003], [0023]-[0024] (user “may walk around a real-world environment and play a virtual game”); Welch¶¶509-515. McCulloch also disclosed that its system can include a video-see display, where the processor supplements the image of the real world with superimposed virtual objects. McCulloch, 3:61-4:3, 26:20-48; Welch¶¶510-511 (POSAs would have known that AR systems frequently are, or at a minimum obviously are, applicable in VR), 512; Zhou (Ex.1107) 1004-09 (game “seamless[ly]

transition[s] from AR to VR”).

Additionally, POSAs would have known that in a VR game, a VR character that talks to a user is a typical (and obvious) virtual object, including in view of the disclosures in Mount 350 and Flaks, which McCulloch incorporates by reference. Mount 350, [0042], [0049] (virtual monsters and people); Flaks, 1:44-46, 1:62-64, 4:10-20, 13:55-14:4 (3D audio engine “localize[s] [] sound as coming from a virtual sound source,” which can be “an object being displayed on [a] display”); Welch¶¶319-322, 510-511 (collecting references); Ross, 17:63-18:9.

b. 2[b]: Localized VR Character Voice

For the same reasons it would have been obvious to externally localize other sounds to SLPs, it would have been obvious to externally localize a VR character’s voice to a VR character’s image (at an SLP). §§V.D.3-V.D.5, V.E.1.a; Welch¶¶516-518; VR Book, 240 (“Spatialized audio” “provide[s] cues of where other characters are located”).

2. Claim 3

a. 3[a]: Tracked HPED Moves in an Arc

McCulloch and Pedrotti each disclosed HMD-tracked handheld controllers (HPEDs) that move in arc-shaped trajectories. McCulloch, 29:11-16 (“movement of the real controller” as “translated into an [] action to be applied to” the virtual object), 27:55-64 (engine for controller’s force feedback applicable to swinging and throwing virtual objects (e.g., McCulloch’s virtual basketball), actions that would

necessitate or obviously encompass moving a controller in an arc); Mount 350, [0024] (disclosing “first person shooting games”); §IV.F.2.a; Welch¶¶519-521.

b. 3[b]: Sound Moves Along Arc

Limitation 3[b]’s HRTF processing would have been obvious for the same reasons as limitation 1[d]’s. §V.D.5. Additionally, it would have been obvious to use HRTFs to process binaural sound that moves through empty space in a virtual environment along an arc trajectory, e.g., as a controller and associated virtual object (e.g., basketball, helicopter, weapon, etc.) moves in that trajectory. POSAs would have known and been motivated to keep visual elements moving in an arc together with associated sounds. Welch¶¶522-524; §IV.E.3 (moving VR objects with their sounds is fundamental).

c. 3[c]: Display Shows Arc

Limitation 3[c] would have been obvious for the same reasons as limitations 3[a] and 3[b]. §§IV.F.2.a-IV.F.2.b. For example, POSAs would have known that when a virtual image displayed by McCulloch’s HMD moves in an arc trajectory with its associated sound—e.g., when a user sees an arcing helicopter or weapon slicing through air or another virtual object—the virtual object would show the user the trajectory of associated binaural sounds moving through the virtual environment’s empty space. Welch¶¶525-526.

3. Claim 4

a. 4[a]: Determine Conflict with Boundary

Limitation 4[a] would have been obvious in view of the Pedrotti disclosures discussed for this limitation in Ground 1. §IV.F.3.a; Welch¶¶527-530.

b. 4[b]: Display Boundary Of Zone

Limitation 4[b] would have been obvious in view of the Pedrotti disclosures discussed for this limitation in Ground 1. §IV.F.3.b. Additionally, POSAs would have understood that McCulloch's system could and would display Pedrotti's boundaries and virtual fence because McCulloch disclosed an HMD with a virtual data engine that displays virtual objects and images and displaying the virtual boundary would ensure that users remained within the safe playspace. §§V.A, V.D; McCulloch, 17:47-48, 23:25-38; Welch¶531.

4. Claim 5

a. 5[a]: Display Zone as Lines

Limitation 5[a] would have been obvious in view of the Pedrotti disclosures discussed for this limitation in Ground 1. §IV.F.4.a; §V.E.3.b; Welch¶¶532-534.

b. 5[b]: Customized Zone

Limitation 5[b] would have been obvious in view of the Pedrotti disclosures discussed for this limitation in Ground 1. §IV.F.4.b. Also, POSAs would have known that McCulloch's playspace boundaries, which are identified via "user input," could be any shape drawn by a user. McCulloch, 20:11-13. And a WED (HMD)

storing coordinate locations of a customized zone would have been obvious in view of McCulloch teaching the use of a scene mapping engine to compare the location of a tracked controller against stored data of a zone based on a common coordinate system. *Id.* 15:30-16:32, Fig. 2A, 8:1-11 (“memory 244” in HMD 2). Such storage was known, and known to be advantageous, and POSAs would have been motivated to store the customized shape in the HMD because it already had built-in memory and HMD storage would make the data readily accessible. Welch¶¶535-539.

5. Claim 6

a. 6[a]: Display a Virtual Monitor

McCulloch disclosed, or at a minimum rendered obvious, imitation 6[a]. McCulloch disclosed displaying virtual objects, as discussed, as well as keeping them within a field of view. McCulloch, 12:29-32 (“A virtual object is generated by an application and is displayed”), 12:3-16 (updating virtual object according to a user’s perspective). In addition, as noted, McCulloch disclosed a virtual television monitor that shatters when a virtual basketball hits it. *Id.* 29:36-63. Also, a virtual monitor is just one example virtual object that McCulloch’s system could display, and POSAs would have known to display such an image because virtual monitors were well known, useful tools for virtual environments, including for providing information to users. Welch¶¶540-542.

b. 6[b]: Sound Comes From Virtual Monitor

It would have been obvious to process sound with HRTFs to generate binaural sound from a virtual monitor (e.g., before or when the monitor is shattered by McCulloch’s basketball) for the reasons discussed in Sections V.D.5 and V.E.2.b. Welch¶¶543-545; §IV.F.5.b.

c. 6[c]: Sound Maintained at Virtual Monitor

McCulloch—via its incorporation of Flaks or in view of Flaks—disclosed, or at a minimum rendered obvious, limitation 6[c]. McCulloch disclosed that its HMD tracks a user’s “movements, head position, and [] orientation” (McCulloch, 8:17-39), and Flaks described processing and producing binaural sound, including in concert with head tracking. §V.D.5; Flaks, 10:5-8 (“determine which way the user’s head is rotated”), 11:25-43 (“inertial sensor is located on the user’s head” to allow tracking of head). POSAs thus would have known and been motivated to process binaural sound originating from a virtual monitor as claimed. Welch¶¶546-547. As discussed in Ground 1, it was known before 2016 that user head movements should be tracked and accounted for to maintain proper locations for the origination of binaural sound while a listener moves. *Id.*¶548; §IV.F.5.c.

6. Claim 7: Cylindrical Zone

Claim 7 would have been obvious for the same reasons as claims 1, 4, and 5 (§§V.D, V.E.3-V.E.4), and in view of the Pedrotti disclosures discussed for this claim in Ground 1. §IV.F.6; Welch¶¶549-550.

F. Claim 8

1. 8[pre]: Method Executed by Electronic Devices

Claim 8's preamble would have been obvious for the same reasons as claim 1's. §V.D.1; Welch¶552.

2. 8[a]: WED Tracking a HPED Defining a Zone

Limitation 8[a] would have been obvious for the same reasons as limitation 1[a]. §V.D.2; Welch¶¶553-554.

3. 8[b]: Designating an SLP

Limitation 8[b] would have been obvious for the same reasons as limitation 1[b]. §V.D.3; Welch¶¶555-556.

Additionally, McCulloch disclosed a controller used to point. McCulloch, 4:25-33, 6:61-66, 25:25-28 (“non-NUI input like moving a displayed selection arrow [a type of pointer] with the real controller device may be used to identify a user selected object for control”), cl. 12. And, as discussed in Ground 1, POSAs would have known to use a handheld controller to select, move, and control virtual objects by pointing at them. Welch¶557; §IV.G.3.

4. 8[c]: Tracked HPED Provides Location of SLP

Limitation 8[c] would have been obvious for the same reasons as limitations 1[c] and 8[b]. §§V.D.4, V.F.3.

In addition, tracking “where the HPED is pointed” would have been obvious because, as noted, “[p]ointing” is “one of the most fundamental and often-used patterns for selection.” VR Book, 327; §IV.G.3; Welch¶¶558-560.

5. 8[d]: Processor Processes Sound with HRTFs

Limitation 8[d] would have been obvious for the same reasons as limitation 1[d]. §V.D.5; Welch¶¶562-563.

6. 8[e]: Display a Virtual Image at the SLP

Limitation 8[e] would have been obvious for the same reasons as limitation 1[e]. §V.D.6; Welch¶564.

G. Dependent Claims 9-13

Claims 9-13 are unpatentable for the same reasons as claim 8 and as further explained below.

1. Claim 9: VR Character Voice

Claim 9 is substantively the same as claim 2, and obvious for the same reasons. §V.E.1; Welch¶¶568-569.

2. Claim 10: VR Game With Zone Lines

Claim 10 would have been obvious for the same reasons as claim 2 and 4 and limitation 5[a], including in view of the Pedrotti disclosures discussed for this claim in Ground 1. §§V.E.1, V.E.3, V.E.4.a; §IV.H.2; Welch¶570.

3. Claim 11: Display Customized Zone

Claim 11 would have been obvious for the same reasons as limitations 1[a] and 5[b]. §§V.D.2, V.E.4.b; Welch¶571.

4. Claim 12: HPED Moves the SLP

Claim 12 would have been obvious over McCulloch, in view of Pedrotti, and further in view of Flaks.

McCulloch disclosed HMD-tracked handheld controllers (HPED) (§V.D.2), and for reasons discussed in the context of limitations 8[b] and 8[c], it would have been obvious to track where McCulloch’s controllers were pointed (§§V.F.3-V.F.4), including when McCulloch’s controller is used to move virtual objects, including SLPs and virtual images, which McCulloch, Flaks, and Pedrotti render obvious (§§V.D.3-V.D.4, V.E.2, V.F.3-V.F.4). Such actions were routine and well known before June 2016, as Dr. Begault admitted. Welch¶¶572-575; Begault Dep., 195:12-196:10.

5. Claim 13: DSP and HRTFs in Cache

McCulloch—via its incorporation of Flaks or in view of Flaks—would have rendered claim 13 obvious for the same reasons as limitations 1[d], 5[b], and 8[d]. §§V.D.5, V.F.5, V.E.4.b.

Additionally, McCulloch disclosed an HMD with “one or more processors,” including “digital processing unit 210” and an audio processing engine. McCulloch, 8:1-16, 8:30-39. POSAs would have known and been motivated to implement

McCulloch's audio processing with a DSP for the same reasons discussed in Ground 1. §IV.H.5; Welch¶¶576-580.

Also, Flaks disclosed using cache memory to improve performance. Flaks, 14:60-67 (cache "improv[es] processing speed and throughput"); McCulloch, 21:21-38, Fig. 4A. Thus, POSAs would have known to use cache in McCulloch's HMD to store HRTFs. Welch¶¶579-580; §IV.H.5.

H. Claim 14

1. 14[pre]: Electronic System

The preamble of claim 14 would have been obvious. McCulloch and Pedrotti disclose electronic systems. §§V.A, IV.A, V.D.1, V.F.1; Welch¶582.

2. 14[a]: PED Defines Zone and Designates An SLP

Limitation 14[a] would have been obvious for the same reasons as limitations 1[a]-1[b] and 8[a]-8[b]. §§V.D.2-V.D.3, V.F.2-V.F.3; Welch¶¶583-584 (McCulloch's controller also is the "PED" in claim 14). POSAs would have known that a user stands on a physical floor. Welch¶585.

3. 14[b]: WED Tracks PED to Determine Boundary

Limitation 14[b] would have been obvious for the same reasons as limitations 1[a] and 8[a]. §§V.D.2, V.F.2; Welch¶586.

4. 14[c]: Processor Processes Sound with HRTFs

Limitation 14[c] would have been obvious for the same reasons as limitations 1[d] and 8[d]. §§V.D.5, V.F.5; Welch¶587; Begault Dep., 197:20-198:12.

5. 14[d]: Display Virtual Images at the SLP and the Zone Boundary

Limitation 14[d] would have been obvious for the same reasons as limitations 1[e], 4[b], 5[a], and 8[e], as well as in view of the Pedrotti disclosures discussed for this limitation in Ground 1. §§V.D.6, V.E.3.b, V.E.4.a, V.F.6, IV.I.5; Welch¶¶588-589.

I. Dependent Claims 15-20

Claims 15-20 are unpatentable for the same reasons as claim 14 and as further explained below.

1. Claim 15: Customized Zone

Claim 15 would have been obvious for the same reasons as limitation 5[b]. §V.E.4.b; Welch¶¶593-595; §IV.J.1.

2. Claim 16

a. 16[a]: Determine PED is at Boundary

Limitation 16[a] would have been obvious for the same reasons as limitations 1[c] and 4[a]. §§V.D.4, V.E.3.a; Welch¶¶596-598; §IV.J.2.a.

b. 16[b]: Display Boundary of Zone

Limitation 16[b] would have been obvious for the same reasons as a limitations 4[b] and 16[a]. §§V.E.3.b, V.I.2.a; Welch¶¶599-600; §IV.J.2.b.

3. Claim 17

a. 17[a]: Determine User is at Boundary

Limitation 17[a] would have been obvious for the same reasons as limitations 1[c] and 4[a]. §§V.D.4, V.E.3.a; Welch¶¶601; §IV.J.3.a.

b. 17[b]: Display Boundary of Zone

Limitation 17[b] would have been obvious for the same reasons as limitation 4[b] and 17[a]. §§V.E.3.b, V.I.3.a; Welch¶¶602-603; §IV.J.3.b.

4. Claim 18

a. 18[a]: Determine Location of User

Limitation 18[a] would have been obvious for the same reasons as limitations 4[a] and 17[a]. §§V.E.3.a, V.I.3.a; McCulloch, 8:17-30 (“location sensing unit 144”); Flaks, 7:33-34 (“listener’s location” “carefully tracked”), 9:18-20 (system “track[s] the physical location of the user”), 11:32-38; Welch¶¶@604-607; §IV.J.4.a.

b. 18[b]: Store Zone for Location

Limitation 18[b] would have been obvious for the same reasons as limitation 5[b]. §§V.E.4.b, IV.J.4.b; §IV.J.4.b. Also, McCulloch disclosed storing a 3D zone because it taught generating and storing 3D maps of environments, and it

would have been obvious to store 3D zones in mapped environments. McCulloch, 15:48-54, 15:63-67; Welch¶¶608-610.

c. 18[c]: Display Boundary if User is There

Limitation 18[c] would have been obvious for the same reasons as limitations 4[b] and 17[a] and 17[b], as well as in view of the Pedrotti disclosures discussed for this limitation in Ground 1. §§V.E.3.b, V.I.3.a, V.I.3.b, IV.J.4.c. Additionally, based on McCulloch’s disclosure of storing 3D maps for when users enter or re-enter virtual environments, it would have been obvious to display the boundary of the zone in response to determining that the user has entered or re-entered the virtual environment and is thus at a location in the zone, e.g., to inform the user of applicable boundaries. McCulloch, 15:48-54, 15:63-67. That would constitute (or at a minimum render obvious) limitation 18[c]’s display of a boundary when a user is determined to be “at the location.” Welch¶¶611-612.

5. Claim 19

a. 19[a]: WED Has Light-Tracking Sensors That Track PED Defining Zone

Limitation 19[a] would have been obvious over McCulloch in view of Pedrotti, including in view of Flaks. McCulloch disclosed using capture devices such as cameras and infrared transceivers (i.e., sensors) in an HMD to detect and track infrared light, including from controllers. McCulloch, 7:34-40 (capture devices), 8:3-39 (transceivers), 5:19-36 (companion processing module 4 in HMD

communicates via infrared with controllers); §V.H.2. Also, as discussed in Ground 1, limitation 19[a]’s tracking of light sources emitted by PEDs was well known and disclosed or rendered obvious by Pedrotti. §IV.J.5.a; Welch¶¶613-614.

b. 19[b]: Display a Virtual Monitor

Limitation 19[b] would have been obvious for the same reasons as limitations 6[a] and 6[b]. §§V.E.5.a-V.E.5.b; Welch¶615.

c. 19[c]: Sound Maintained at Virtual Monitor

Limitation 19[c] would have been obvious for the same reasons as limitations 6[b] and 6[c]. §§V.E.5.b-V.E.5.c; Welch¶616.

6. Claim 20: Display Zone as Lines

Claim 20 would have been obvious for the same reasons as limitations 4[b] and 5[a] and claim 10. §§V.E.3.b, V.E.4.a, V.G.2. POSAs would have known that a user could determine a boundary when it is displayed. Welch¶¶617-618.

VI. Secondary Considerations

Petitioners are unaware of any secondary considerations that affect—let alone overcome—the obviousness cases set out above. Should Patentee proffer any secondary considerations evidence in its preliminary response, Petitioners should be permitted to reply.

VII. The Board Should Reach the Merits of This Petition

The Board should reach the merits of this petition and should not exercise its discretion to deny based on 35 U.S.C. § 314(a) or § 325(d). None of the prior art at

issue in this petition was cited or relied upon during prosecution of the '737 patent. As for the district court case, the court is currently deciding a motion to transfer. *Eight kHz v. Meta Platforms*, No. 6:22-cv-00575, Dkt. 46 (W.D. Tex.).

Petitioners reserve the right to address any discretionary issues raised by Patentee based on the facts and law as they stand at that time.

VIII. Mandatory Notices Under 37 C.F.R. § 42.8(B)

A. Real Parties-In-Interest

Petitioners are the only real parties-in-interest.

B. Related Matters

Patent Center indicates that U.S. Patent Application Nos. 62/348,164, 15/365,880, 15/429,131, 15/635,166, 17/169,481, and 17/988,808, currently pending, are related to the '737 patent, which issued from Application No. 16/558,088.

The '737 patent is at issue in *Eight KHZ v. Meta Platforms*, No. 6:22-cv-00575 (W.D. Tex.).

C. Grounds for Standing

Petitioners certify that the '737 patent is available for IPR and Petitioners are not barred from requesting same.

D. Counsel and Service Information

Pursuant to 37 C.F.R. §§ 42.8(b)(3), 42.8(b)(4), and 42.10(a), Petitioners designate the following lead counsel:

- Inge A. Osman (Reg. No. 74,480), inge.osman@lw.com, Latham & Watkins LLP; 555 Eleventh Street, NW, Ste. 1000; Washington, DC 20004-1304; 202.637.3308 (Tel.); 202.637.2201 (Fax).

Petitioners also designate the following backup counsel:

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Pursuant to 37 C.F.R. § 42.10(b), a Power of Attorney from Petitioners is attached. Petitioners consent to electronic service.

E. IPR Fee

The Director is authorized to charge the requisite fee to Deposit Account No. 506269.

IX. Conclusion

IPR should be instituted, and each challenged claim should be found unpatentable.

Respectfully submitted,

Dated: June 9, 2023

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Claims Appendix

This “Claims Appendix” reproduces the challenged claims, with bracketed identifiers added for cross-referencing.

Claim 1:

[pre] A method executed by one or more electronic devices, the method comprising:

[a] tracking, with a wearable electronic device (WED) worn on a head of a user, movement of a handheld portable electronic device (HPED) held in a hand of the user such that the movement of the HPED defines a size and a shape of a three-dimensional (3D) zone that extends from a physical floor and around the user;

[b] designating, with the HPED held in the hand of the user, a sound localization point (SLP) in empty space in the zone above the physical floor from where binaural sound originates to the user;

[c] tracking, with the WED worn on the head of the user, the HPED held in the hand of the user such that the HPED provides a location to the WED of the SLP in empty space in the zone above the physical floor from where the binaural sound originates to the user;

[d] 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; and

[e] displaying, with the WED worn on the head of the user, a virtual image at the location of the SLP in empty space in the zone above the physical floor from where the binaural sound originates to the user.

Claim 2:

[a] The method of claim 1, wherein the binaural sound is a voice of a virtual reality (VR) character that talks to the user while the user plays a VR game,

[b] and the voice externally localizes to the user at the VR character that is at the location of the SLP in empty space in the zone above the physical floor.

Claim 3:

[a] The method of claim 1 further comprising: tracking, with the WED worn on the head of the user, the HPED held in the hand of the user as the HPED moves in a trajectory having a shape of an arc;

[b] processing, by the processor and with the HRTFs, the sound to generate SLPs of the binaural sound that moves through the empty space along the trajectory having the shape of the arc; and

[c] displaying, with the WED worn on the head of the user, virtual images that follow the trajectory having the shape of the arc that shows the user the trajectory of the SLPs of the binaural sound moving through the empty space.

Claim 4:

[a] The method of claim 1 further comprising: determining, with the WED worn on the head of the user, when a location of the user conflicts with a boundary of the zone; and

[b] displaying, with the WED, the boundary of the zone to alert the user that the location of the user conflicts with the boundary of the zone.

Claim 5:

[a] The method of claim 1 further comprising: displaying, with the WED worn on the head of the user, a virtual image of the zone as lines that extends from the physical floor and around the user,

[b] wherein the zone has a customized shape drawn by user with the HPED, and the WED stores coordinate locations of the customized shape.

Claim 6:

[a] The method of claim 1 further comprising: displaying, with the WED, a virtual monitor in a field of view (FOV) of the user;

[b] processing, by the processor, the sound with the HRTFs to generate the binaural sound that originates from the virtual monitor; and

[c] tracking, with the WED, head movements of the user to maintain the binaural sound originating from the virtual monitor as the head of the user moves.

Claim 7:

The method of claim 1, wherein the zone has a shape of a cylinder that extends from the physical floor and around the user, and the WED displays the cylinder to the user.

Claim 8:

[pre] A method executed by one or more electronic devices, the method comprising:

[a] tracking, with a wearable electronic device (WED) worn on a head of a user, a handheld portable electronic device (HPED) that moves to define a shape of a zone that extends from a physical floor and around the user holding the HPED in a hand;

[b] designating, with the HPED held in the hand of the user, a sound localization point (SLP) for binaural sound at a location in empty space in the zone above the physical floor where the HPED is pointed;

[c] tracking, with the WED worn on the head of the user, the HPED and where the HPED is pointed to provide the WED with the location in empty space in the zone above the physical floor that includes the SLP for the binaural sound;

[d] processing, by a processor, sound with head-related transfer functions (HRTFs) to produce the binaural sound that originates at the SLP at the location in empty space in the zone above the physical floor; and

[e] displaying, with the WED worn on the head of the user, a virtual image at the location in empty space in the zone above the physical floor from where the binaural sound originates at the SLP to the user.

Claim 9:

The method of claim 8 further comprising: providing a voice as the binaural sound that externally localizes at the virtual image at the location in empty space in the zone above the physical floor, wherein the voice originates from a character in a virtual reality (VR) game that the user plays.

Claim 10:

The method of claim 8 further comprising: displaying, with the WED, a boundary of the zone with virtual lines to alert the user when the user conflicts with the boundary of the zone while the user plays a virtual reality (VR) game.

Claim 11:

The method of claim 8 further comprising: displaying the zone as a customized three-dimensional (3D) shape drawn by the user with the HPED held in the hand of the user.

Claim 12:

The method of claim 8 further comprising: tracking, with the WED, a location where the HPED is pointed as the HPED moves the SLP and the virtual image from one location where the HPED is pointed to another location where the HPED is pointed.

Claim 13:

The method of claim 8 further comprising: improving performance of the processor processing the sound by storing the HRTFs in a cache memory in the WED, wherein the processor is a digital signal processor (DSP) located in the WED.

Claim 14:

[pre] An electronic system, comprising:

[a] a portable electronic device (PED) that moves to define a boundary of a three-dimensional (3D) zone extending from a physical floor on which a user holding the PED stands and around the user and that designates a sound localization point (SLP) in empty space inside the 3D zone; and

[b] 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,

[c] 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

[d] 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.

Claim 15:

The electronic system of claim 14, wherein the 3D zone has a customized size and shape defined by movement of the PED while held in a hand of the user.

Claim 16:

[a] The electronic system of claim 14, wherein the WED tracks the PED to determine when the PED is at the boundary of the 3D zone, and

[b] 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 17:

[a] The electronic system of claim 14, wherein the WED tracks the user to determine when the user is at the boundary of the 3D zone, and

[b] the WED automatically displays the 3D virtual image that shows the boundary of the 3D zone to alert the user that the user is at the boundary of the 3D zone.

Claim 18:

[a] The electronic system of claim 14, wherein the WED determines a location of the user,

[b] stores the 3D zone for the location, and

[c] displays the 3D virtual image that shows the boundary of the 3D zone in response to determining that the user is at the location.

Claim 19:

[a] The electronic system of claim 14, wherein the WED includes one or more sensors that track a light source in the PED to determine a location of the PED as the PED moves to define the boundary of the 3D zone,

[b] the WED displays a virtual monitor at the SLP in empty space inside the 3D zone, and

[c] the binaural sound continues originates to the user at the virtual monitor as the head of the user rotates to different orientations with respect to the virtual monitor.

Claim 20:

The electronic system of claim 14, wherein the WED displays the 3D virtual image that shows the boundary of the 3D zone as lines to enable the user to determine the boundary of the 3D zone.

CERTIFICATE OF COMPLIANCE WITH 37 C.F.R. § 42.24

I hereby certify that this Petition complies with the word count limitation of 37 C.F.R. § 42.24(a)(1)(i) because the Petition contains a total of 13,947 words, which is the sum of 13,933 words calculated by Microsoft Word's word-count feature and 14 words hand-counted in the figures. This total excludes the cover page, signature block, and the parts of the Petition exempted by 37 C.F.R. § 42.24(a)(1).

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CERTIFICATE OF SERVICE

The undersigned certifies that a complete copy of this Petition for *Inter Partes* Review of U.S. Patent No. 10,917,737 and all Exhibits and other documents filed together with this Petition were served on the official correspondence address for the patent shown in Patent Center:

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