

Supplemental Declaration of Dr. Gregory F. Welch

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
META PLATFORMS TECHNOLOGIES, LLC, and
TWISTED PIXEL GAMES, LLC,
Petitioner,

v.

EIGHT KHZ, LLC,
Patent Owner.

IPR2023-01023
Patent 10,798,509 B1

**SUPPLEMENTAL DECLARATION OF DR. GREGORY F. WELCH
IN SUPPORT OF PETITIONERS' REPLY**

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I. Introduction and Qualifications

1. I, Gregory F. Welch, submit this supplemental declaration on behalf of Meta Platforms, Inc. and Meta Platforms Technologies, LLC (collectively, “Meta” or “Petitioners”) to provide my opinion concerning the validity of the claims 1-14 and 17-20 of U.S. Patent No. 10,798,509 (“the ’509 patent,” Ex.1001-509), in support of Petitioners’ Reply for IPR2023-01023.

2. I previously provided a declaration dated June 8, 2023 with my opinions related to the level of skill of ordinary artisans, the state of the art described in the ’509 patent at the time of the ’509 patent’s earliest claimed priority date (February 20, 2016), and the disclosure of the prior art relative to claims 1-14 and 17-10 of the ’509 patent. I understand that my original declaration was submitted as Exhibit 1003. I hereby incorporate Exhibit 1003 into this declaration by reference.

3. My experience and qualifications are set forth in Exhibit 1003 and in my *curriculum vitae*, which I understand was submitted as Exhibit 1004. Since the submission of Exhibit 1004, there have been some updates to my *curriculum vitae*, including additional papers and grant updates, which are reflected in the version available at https://sreal.ucf.edu/wp-content/uploads/2022/08/welch_cv.pdf.

4. I have been asked to provide additional expert opinions regarding these matters in response to certain arguments in the Patent Owner’s Response. I do not respond directly to the opinions of Patent Owner’s witness, Dr. John C. Hart,

because I understand that Patent Owner has disclaimed Dr. Hart's earlier opinions and no longer relies on them or Dr. Hart in this *inter partes* review. POR at 2.

II. Summary of Materials Reviewed and Considered

5. All of the opinions contained in this declaration are based on the documents I reviewed and my knowledge and professional judgment. In forming the opinions expressed in this declaration, while drawing on my experience, I reviewed the following documents, in addition to the Institution Decision (Paper 10) and Patent Owner's Response (Paper 21) in this IPR:

Exhibit	Description
1001-509	U.S. Patent No. 10,798,509 ("509 patent")
1003	Declaration of Dr. Gregory Welch in Support of Petition for <i>Inter Partes</i> Review of the '509 Patent (my "Opening Declaration" or "Op. Decl.")
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")
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")

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Exhibit	Description
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”)
1026	U.S. Patent No. 10,509,466 (“Miller 466”)
1027	U.S. Patent Application No. 13/288350 (“Mount 350”)
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”)
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”)
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”)

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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”)
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1055	Steve DiPaola & David Collins, <i>A 3D Virtual Environment for Social Telepresence</i> , W. Comput. Graphics Symp., Mar. 24-27, 2002 (“DiPaola”)
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 & Computer Graphics 204-12 (2007)
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1059	Foster, Cornell Univ. (SP2012), Lecture 25 <i>Memory and Locality</i> , 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-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)
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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
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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/
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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., Apr. 1981)

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1093	Ivan E. Sutherland, <i>A Head-Mounted Three Dimensional Display</i> , Fall Joint Comput. Conf. 757-64 (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. 14, 2015) 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)
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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

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1104	Elizabeth M. Wenzel et al., <i>A Virtual Display System for Conveying Three-Dimensional Acoustic Information</i> , Proc. Hum. Factors Soc'y – 32nd Annual 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")
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) ("Azuma")
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")

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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
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1120	Steven M. Kaplan, <i>Wiley Electrical and Electronics Engineering Dictionary</i> 71, 335 (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 (W.D. Tex. Oct. 10, 2022)
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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”)
1129	Plaintiff’s Infringement Contentions, Exhibit 15, <i>Eight Khz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575 (W.D. Tex. Mar. 3, 2023)
1130	Plaintiff’s Infringement Contentions, Exhibit 17, <i>Eight Khz, LLC v. Meta Platforms, Inc.</i> , No. 6:22-cv-00575 (W.D. Tex. Mar. 3, 2023)
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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, “No Silver Bullet”)
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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
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Exhibit	Description
1143	Declaration of Dr. Gregory Welch in Support of Petition for Inter Partes Review of U.S. Patent No. 10,917,737 (Welch Deposition Exhibit 3)
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1147	Grigore Burdea et al., <i>Multimodal Virtual Reality: Input-Output Devices, System Integration, and Human Factors</i> , 8 INT’L J. HUM.–COMPUT. INTERACTION 5 (“Burdea”)
1148	Kellie Rae Carter, <i>Gaming the Design: Using Game Design Techniques in the Realm of Investing</i> , 35 BULL. AM. SOC’Y INFO. SCI. & TECH 20 (2009) (“Carter”)
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1154	Second Life: The Official Guide, Suzanne’s Guitar (video)
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1163	<i>How to Use Oculus Rift with Second Life</i> , YOUTUBE.COM (May 22, 2014), https://www.youtube.com/watch?v=TLL5JVwG118
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Exhibit	Description
1170	Transcript, Excerpt of Chapter 1-2 <i>Resident Evil 4 (2005) PC No Commentary Walkthrough & Gameplay 2</i> , YOUTUBE.COM (Feb. 28, 2008), https://www.youtube.com/watch?v=PS5a6bVMHxw
1171	Errata Sheet to Transcript of Welch Deposition (May 3, 2024)
1172	B. Danette Allen et al., <i>Tracking: Beyond 15 Minutes of Thought</i> , UNIV. OF N. CAROLINA AT CHAPEL HILL (Aug. 11, 2001), http://www.cs.unc.edu/tracker/ref/s2001/tracker/ (“Allen”)
2012	Transcript of May 3, 2024 Deposition of Dr. Gregory Welch (“Welch Dep. Tr.”)

III. Legal Understandings

6. I am not an attorney. However, as noted in my previous declaration, I have been informed by counsel of certain legal standards and have applied those standards, described in Exhibit 1003, in formulating my opinions. Welch (Ex.1003) ¶¶ 17-26.

IV. Patent Owner’s Challenges to My Methodology and Understandings Are Misplaced

7. I understand that Patent Owner argues in the Patent Owner’s Response that I “admitted that [I] failed to ‘explain what elements of the claims meant to anybody,’” and “acknowledged [my] failure to undertake any ‘careful analysis’ to form an ‘understanding’ of specific limitations of the Challenged claims.” POR at 4. I disagree. Indeed, nothing could be further from the truth.

8. As I explained in my opening declaration, in my analysis of the '509 patent—including my careful analysis of each limitation of each of challenged claims 1-14 and 17-20, and every challenged claim as a whole—I fully understood and applied the plain and ordinary meanings of the claim terms in the '509 patent, as a person of ordinary skill in the art would have understood and applied them in the context of that patent in approximately February 2016. Op. Decl. ¶ 38. But, as I also explained in my opening declaration, and during my May 3, 2024 deposition, my analysis did not depend on any particular, express claim constructions, because I did not find that to be necessary to provide my opinions regarding the relationship between the prior art and the claims of the '509 patent. *Id.*; Welch Dep. Tr. (Ex.2012) 192:13-193:4, 305:18-306:4. The Board similarly recognized in its Institution Decision that no particular, express constructions of claim terms are necessary in this *inter partes* review. Institution Decision at 10.

9. I further understand that Patent Owner argues that I “deconstructed the Challenged Claims into [] individual limitations and then attempted to construct a narrative from the prior art to explain why each limitation was taught” and “use[d] [my] expert status to ‘supply’ key limitations ‘missing from the prior art’ via conclusory assertions.” POR at 4. Here too, I disagree, and Patent Owner’s critiques are once again misplaced.

10. In my opening declaration, I carefully analyzed every limitation of every challenged claim, and every challenged claim as a whole. In doing so, I explained why the prior art relied on in the Petition's Grounds 1 and 2 rendered obvious every challenged claim, including in view of the state of the art as of the '509 patent's earliest claimed priority date. And at each step, I identified disclosures from the Ground 1 and Ground 2 prior art references supporting my opinions, and where appropriate and helpful, I identified and discussed background prior art evidencing the level of knowledge skilled artisans would have brought to the Ground 1 and Ground 2 prior art references. I maintain this approach, which I understand is the correct one, in this declaration.

11. Patent Owner presented other—equally unavailing—critiques of my opinions in the Patent Owner's Response, which I discuss below, in the context of the particular Grounds, claims, and limitations to which those critiques relate.

V. Ground 1

A. Skilled Artisans Would Have Known and Been Motivated to Combine Pedrotti and Jang, and Pedrotti, Jang, and Begault

12. In my opening declaration, I explained why persons of ordinary skill in the art would have known and been motivated to combine the teachings of Pedrotti and Jang (Op. Decl. §X.A.1), and why persons of ordinary skill in the art would have

known and been motivated to combine the teachings of Pedrotti, Jang, and Begault (Op. Decl. §X.A.2). Those opinions, as noted, are fully incorporated here.

13. In the Patent Owner’s Response, Patent Owner does not contest my opinions relating to the reasons skilled artisans would have combined the Ground 1 prior art references, including my opinions that the prior art references relied on in Ground 1 are analogous prior art.¹ Nevertheless, because I understand that the Board invited additional information relating to why Petitioners’ prior art is analogous art in an Institution Decision relating to Patent Owner’s U.S. Patent No. 11,172,316 (the “316 patent”)—a patent I addressed in the same opening declaration I used to address the ’509 patent—I provide such information here. *See* IPR2023-01022, Paper 10 at 25 n.10.²

¹ Patent Owner’s prior witness, Dr. Hart, discussed my opinions relating to reasons persons of ordinary skill in the art would have combined the Ground 1 prior art references in a declaration submitted before the Board’s Institution Decision; however, as noted, Patent Owner has disclaimed and no longer relies on Dr. Hart’s opinions. POR at 2.

² I understand that IPR2023-01022 has been terminated.

14. I understand that a prior art reference is analogous prior art for purposes of an obviousness analysis if it is *either* (1) from the same field of endeavor, regardless of the problem addressed, *or* (2) if not within the same field of endeavor, still reasonably pertinent to the particular problem with which the inventor(s) were involved. The Ground 1 prior art—Pedrotti, Jang, and Begault—is analogous art to the '509 patent; indeed, as I explain below, each reference satisfies both of these conditions.

15. The '509 patent purports to relate to VR and AR systems involving wearable electronic devices and sound processing techniques used for same. *See, e.g.,* '509 patent (Ex.1001-509) at Title (“Wearable Electronic Device Displays a 3D Zone From Where Binaural Sound Emanates”), Abstract (“A portable electronic device (PED) divides an area around a user into a three-dimensional (3D) zone. A wearable electronic device worn on a head of the user displays the 3D zone in response to the wearable electronic device detecting that the user is leaving the zone. The wearable electronic device plays binaural sound that emanates to the user from sound localization points (SLPs) inside the zone.”); *see also* '509 patent (Ex.1001-509) at 18:27-57, 20:37-57, 21:64-22:7. And the claims of the '509 patent encompass dividing an area into a zone with multiple sound localization points (SLPs), and performing additional steps relating to VR and AR experiences, such as

ensuring that a user stays within a zone and controlling virtual objects and audio presented to the user. *See, e.g.*, '509 patent (Ex.1001-509) at cls. 1, 9, 17.

16. Pedrotti is analogous art to the '509 patent because it is from the same field of endeavor, and it is reasonably pertinent to the problems with which the inventor(s) were allegedly involved (*e.g.*, determining when users leave VR zones). Pedrotti describes a VR system involving an HMD, i.e., a WED worn on a user's head, and discloses, among other things, ways to control virtual objects presented to users with the HMD, including to ensure users stay within "safe area" zones. *See, e.g.*, Pedrotti (Ex.1005) at 1:8-10 ("The present invention relates generally to virtual reality devices ..."), 2:27-32 ("One embodiment discloses a method of assisting a user wearing a head-mounted display (HMD) in remaining within a selected area of the physical world, the user holding a handheld controller having a controller tracker which provides information regarding a position of the handheld controller"); *see also* Op. Decl. §IX.A (Overview of Pedrotti).

17. Jang, like Pedrotti, is analogous art to the '509 patent because it is from the same field of endeavor, and it is reasonably pertinent to the problems with which the inventor(s) were allegedly involved (*e.g.*, controlling binaural sounds in VR). Jang is directed to the field of VR, and Jang describes, among other things, systems with HMDs and the use of such systems to present and control virtual objects and sound in virtual environments, including binaural sound. *See, e.g.*, Jang (Ex.1006)

at 1:18-23 (“The present general inventive concept relates to an apparatus and a method to perform sound processing in a virtual reality system”), 1:28-30 (“Virtual reality systems may be used to provide a high degree of realism in an electronically-manufactured environment, such as in a virtual reality game or a 3D game.”), 1:46-51 (disclosing sound processing techniques to “model[] the path and change of sound according to relative locations of a sound-generating object, locations of surrounding things, and direction of sound propagation to give the sense of reality to the sound”), 2:26-28 (disclosing “sound processing [that] may control the sound output with a sense of realism in consideration of a space shift in a virtual reality system”); *see also* Op. Decl. §IX.B (Overview of Jang).

18. Begault, like Pedrotti and Jang, is analogous art to the ’509 patent because it is from the same field of endeavor, and it is reasonably pertinent to the problems with which the inventor(s) were allegedly involved (*e.g.*, controlling binaural sounds in VR). Begault is directed to the field of “3-D Sound for Virtual Reality and Multimedia” (Begault, Title), and it discloses, among other things, techniques for presenting and controlling binaural sound. *See, e.g.*, Begault (Ex.1007) at ch. 2 (discussing in detail HRTFs and localization with HRTF cues), 13 (“[o]ne might be able to work more effectively within a VR environment if actions [a]re accompanied by appropriate sounds that seemingly emit from their proper locations”), 170 (disclosing various examples in which “distributed 3-D

audio devices” were “integrated within a dedicated virtual reality application”); *see also* Op. Decl. §IX.C (Overview of Begault).

B. Claims 1-14 and 17-20 Would Have Been Obvious Over Pedrotti and Jang, and Over Pedrotti, Jang, and Begault

19. In this section, I address Patent Owner’s arguments about the Ground 1 prior art and the obviousness of challenged claims 1-14 and 17-20. As I understand the Board’s Institution Decision discussed independent claim 9 first, I do the same.

1. Independent Claim 9

20. I understand that Patent Owner contends that neither the combination of Pedrotti and Jang nor the combination of Pedrotti, Jang, and Begault teaches or suggests limitations 9[b], which recites, “determining, with a wearable electronic device (WED) worn on a head of the user, when the user is located inside the zone,” and limitation 9[c], which recites “determining, with the WED worn on the head of the user, when the user is leaving the zone.” POR at 29. I disagree.

21. Patent Owner argues that “the determination of whether the user is inside the zone or not” must “be made exclusively with the WED,” contending that “this requires that the processor responsible for making the determination is located in the WED,” but Pedrotti does not teach or suggest an HMD that can “track itself or the user without the use of a separate base station.” POR at 29-32. Patent Owner’s argument fails, however, because, as Patent Owner admits elsewhere, limitations

9[b] and 9[c] do not preclude the use of a base station (POR at 29), and limitations 9[b] and 9[c] do not require that their determining steps “be made *exclusively* with the WED”; that is not what these limitations say, or how a person of ordinary skill in the art would understand them. As the Board recognized in its Institution Decision:

Patent Owner’s arguments are unavailing as they are based on the assumption that Petitioner’s proposed combination eliminates Pedrotti’s base station and that limitation 9[b] precludes the use of a base station with the WED. Neither of these assumptions is correct. Nothing in Petitioner’s challenge indicates that the proposed combination eliminates the use of Pedrotti’s base station. Moreover, nothing in claim 9 precludes the use of a base station in conjunction with the WED to track the user. Claim 9 merely recites a non-transitory computer readable storage medium storing instructions executed as a method “comprising” determining, “with” the WED, when the user is located inside the zone and leaving the zone, but does not expressly preclude other devices from being involved in those determinations.

Institution Decision at 18.

22. Accordingly, even the illustrative embodiments that Pedrotti describes that utilize a base station and electromagnetic tracking—which Patent Owner

emphasizes to the exclusion of all of Pedrotti's other disclosures, POR at 19-23—render obvious limitations 9[b] and 9[c]. Pedrotti teaches that this exemplary system determines when users are located inside safe area zones and when users leave such zones “*with*” the user's HMD (the claimed WED) because Pedrotti's HMD comprises an “HMD tracker” that “provides information about the sensed magnetic field to a processor,” “which derives the position and orientation of the tracker 108, and thus HMD 106” (i.e., the user), “relative to a source of the electromagnetic field from such information,” so Pedrotti can “generate[] 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.” *See, e.g.*, Pedrotti (Ex.1005) at 4:37-5:7. Pedrotti thus discloses, or at a minimum suggests and renders obvious, “determining, *with* a wearable electronic device (WED) worn on a head of the user, when the user is located inside the zone,” as recited in limitation 9[b], and “determining, with the WED worn on the head of the user, when the user is leaving the zone,” as recited in limitation 9[c]. Persons of ordinary skill in the art would not understand these limitations to require the processing exclusivity Patent Owner attributes to them.

23. Regardless, Pedrotti also teaches or at a minimum suggests, and thus renders obvious, a processor in an HMD performing the determining steps of limitations 9[b] and 9[c]. And persons of ordinary skill in the art also would have

known and been motivated to incorporate such a processor into an HMD in view of the state of the art in February 2016.

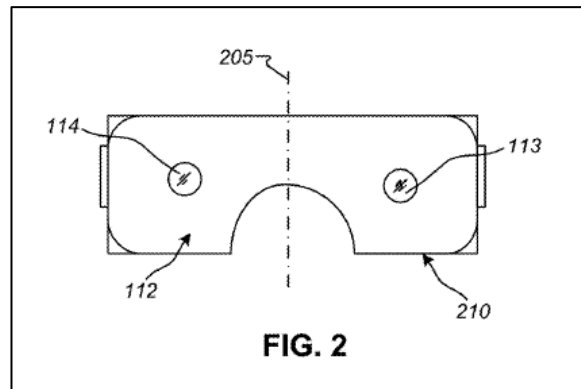
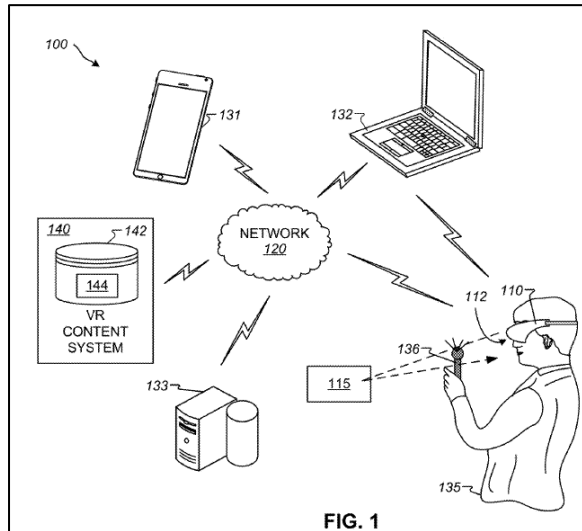
24. Pedrotti teaches that a base station may be a simple cradle or dock without a processor: “In other embodiments, the base station may be only a cradle or dock upon which the controller may rest, perhaps with a groove or contour that conforms to the shape of the controller, *with the processor and/or other components located elsewhere.*” Pedrotti (Ex.1005) at 5:64-6:1 (emphasis added); *see also* Pedrotti (Ex.1005) at 6:1-2 (“Alternatively, some components may be in the base station and some components located elsewhere.”). Pedrotti further teaches: “If components such as the electromagnetic field source or camera used to determine the position of the HMD and controller trackers relative to the base station are not located in the base station, it will be desirable for the base station to also contain a tracker similar to those used in the HMD and controllers, so that the position of the base station is known and thus the positions of the HMD and controllers relative to the base station can be determined.” Pedrotti (Ex.1005) at 6:2-10. Persons of ordinary skill in the art reviewing such disclosures would have understood that Pedrotti’s tracking can be performed by a processor that is not located in a base station, including but not limited to when the base station is a simple cradle or dock. And Pedrotti expressly discloses that its processor may be “in the HMD”:

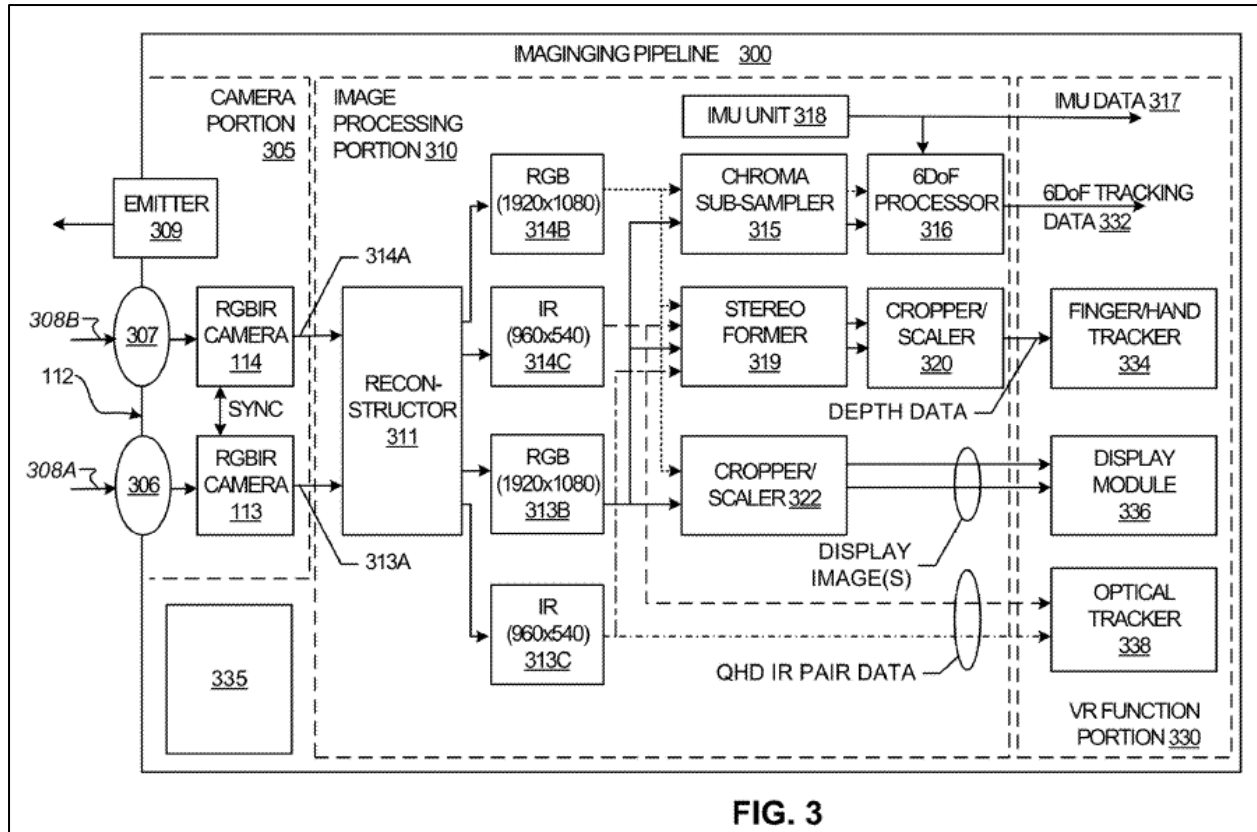
There may be a single processor, or multiple processors performing different functions of the functions described herein. As above, a processor may be located in the base station, or in a separate location, or even *in the HMD* or one of the controllers if desired. One of skill in the art will appreciate how to determine which and how many processors will be appropriate for a specific intended application.

Pedrotti (Ex.1005) at 16:20-26 (emphasis added).

25. Furthermore, as I explained during my deposition, Pedrotti provides examples of different types of tracking systems and methods that do not require a tracking processor in a base station. Welch Dep. Tr. (Ex.2012) at 240:9-21; Pedrotti (Ex.1005) at 4:59-5:24 (describing different tracking systems, methods, and techniques), 16:27-32 (“Similarly, as explained above, various tracking techniques may be used in addition to electromagnetic tracking, and in some embodiments some of the other components used for tracking, such as an electromagnetic field source or a camera, may be located in the base station, while in other embodiments they may be located elsewhere.”). And many such tracking systems would have been well-known to persons of ordinary skill in the art, as Pedrotti states. Pedrotti (Ex.1005) at 4:59-61. I discussed multiple examples in my opening declaration. *See* Op. Decl. §VII.D, including ¶¶ 88-97 (discussing known systems with processors used for tracking in HMDs).

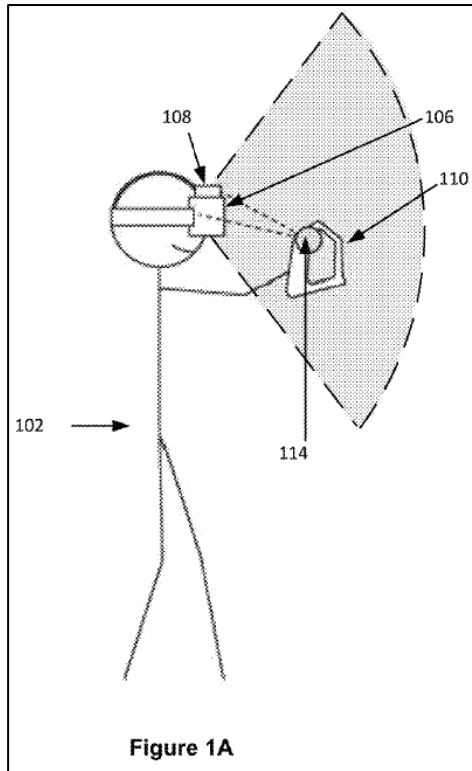
26. For instance, U.S. Patent No. 10,114,465 (“Wan”) describes a VR HMD (numbered item 110 with front face 112) and an “example imaging pipeline 300 [that] includes any number and/or type(s) of a 6DoF processor(s) 316,” which “provides determined 6DoF tracking data 332.” Wan (Ex.1040) at 6:64-7:9; *see also* Wan (Ex.1040) at 2:41-51 (describing “V-HMDs designs” that include many examples of cameras for tracking, including “cameras for tracking a VR controller, etc.”).





Wan (Ex.1040) at Figs. 1-3.

27. As another example, a related patent to Pedrotti, U.S. Patent No. 10,162,177 (“Pedrotti 177”) discloses that “a processor may be located in the HMD.” Pedrotti 177 (Ex.1032) at 10:63-65. I note that Fig. 1A of Pedrotti 177 also shows an HMD 106 with a magnetic field source 108 on the HMD, which is used to track a hand-held controller 110 to which a tracker 114 with sensor magnetic coils is attached, i.e., a system that does not use a base station for electromagnetic tracking:



Pedrotti 177 (Ex.1032) at Fig. 1A; *see also* Pedrotti 177 (Ex.1032) at 4:63-5:23 (describing same), 4:26-29 (“A head-mounted magnetic tracking (HMMT) system is used, in which other parts of a user’s body are tracked relative to the HMD on the user’s head, rather than relative to a base station.”).

28. As these and other references I discussed in my opening declaration demonstrate, systems with HMDs containing processors for tracking were well-known by February 2016. *See* Op. Decl. §VII.D. And, to be clear, even if limitations 9[b] and 9[c] required a processor in an HMD to exclusively make those limitations’ determinations as Patent Owner argues (Patent Owner is wrong, for reasons I noted above), skilled artisans reading Pedrotti would have known and been

motivated to implement Pedrotti's system that way, consistent with Pedrotti's teachings. The benefits of such systems also were well-known.

29. For example, incorporating a processor into an HMD—as opposed to a base station—would decrease the likelihood of breaks-in-presence. A “break-in-presence” is “a moment when the illusion generated by a virtual environment breaks down and the user finds himself where he truly is—in a laboratory wearing an HMD ... These breaks-in-presence can destroy a VR experience and should be avoided as much as possible. Example causes of a break-in-presence include loss of tracking, a person speaking from the real world that is not part of the virtual environment, tripping on a wire, a real-world phone ringing, etc.” Jerald, *THE VR BOOK* (Ex.1063) at 46-47. And skilled artisans would have understood that eliminating additional external components and communication issues (*e.g.*, a base station, wires associated with a base station, disruptions in connectivity to a base station, and increased tracking latency) by incorporating a tracking processor into an HMD would help reduce the likelihood of such breaks-in-presence.

30. Additionally, skilled artisans would have known and been motivated to reduce the number of physical components required for tracking—and general use of a VR system—for convenience, portability, cost, and ease of manufacturing and fulfillment logistics. *See, e.g.*, Piper Jaffray (Ex.1150) at 22 (predicting a “switch to all-in-one wireless headsets with a built in display” because “next generation sensors

will be available along with, custom displays and custom optics which make VR headsets portable and fashionable”).

31. As I discussed in my opening declaration, by at least the early 2000s “smart” phones and other mobile devices included sensors that provided pose estimation and tracking that employed inertial sensors, electromagnetic compasses, cameras, and powerful processors. Indeed, the commoditization of mobile devices such as the Apple iPhone in 2007 drove dramatic improvements in the related components (*e.g.*, sensors, displays, and processors) in terms of size, weight, power, performance, and cost. As I also discussed in my opening declaration, these improvements in smart devices and the associated components heralded the development of AR and VR systems that were self-contained within single head-worn units that included processors, wireless networking, motion tracking, graphics rendering, and high-resolution displays. *See* Op. Decl. §VII, *e.g.*, §VII.A and §VII.D. These advances in the basic components, and their widespread use in commercially available self-contained AR and VR systems, would have motivated skilled artisans to incorporate Pedrotti’s tracking processor and other components into Pedrotti’s HMD (rather than a separate base station).

32. For at least these reasons, as well as those set out in my opening declaration, it is my opinion that Pedrotti discloses, or at a minimum renders obvious,

limitations 9[b] and 9[c], and Patent Owner's arguments about these limitations are misplaced and incorrect.

2. Limitations 1[c] and 1[d] and Dependent Claims 10 and 11

33. I understand that Patent Owner contends that neither the combination of Pedrotti and Jang nor the combination of Pedrotti, Jang, and Begault teaches or suggests limitation 1[c], limitation 1[d], claim 10, or claim 11. POR at 5-11, 32-33. I further understand that the portions of these limitations and claims on which Patent Owner focuses relate to (1) highlighting an SLP when a handheld PED is pointed at the SLP while a user is located in the zone, and (2) playing binaural sound in response to pointing. Below, I discuss and explain why I disagree with each of Patent's Owner's incorrect arguments about these issues.

a. Limitation 1[c] and Claim 11: Highlighting an SLP at Which a PED is Pointed

34. Limitation 1[c] recites: "highlighting, while the user is located in the zone and with a display of the WED, one of the multiple SLPs in the zone when the PED held in the hand of the user is pointed at the one of the multiple SLPs in the zone." '509 patent (Ex.1001-509) at cl. 1. Claim 11 recites: "highlighting, while the user is located in the zone and with a display of the WED, a virtual image at one of the SLPs in the zone when the PED held in the hand of the user is pointed at the one of the multiple SLPs in the zone." '509 patent (Ex.1001-509) at cl. 11.

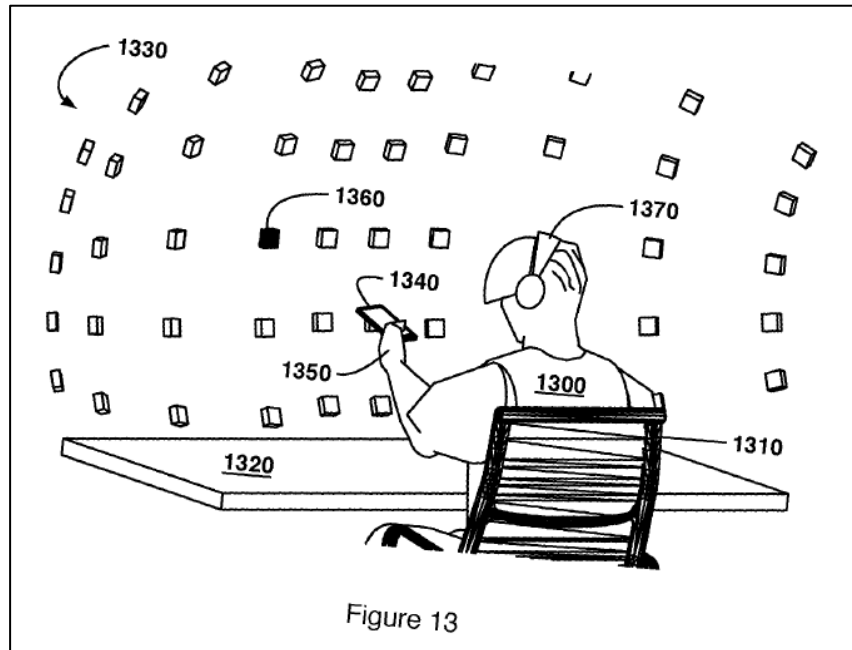
(1) Patent Owner's Arguments About Pedrotti are Misplaced and Incorrect

35. As I explained in my opening declaration (Op. Decl. ¶¶ 267-269), Pedrotti, in combination with Jang and/or in combination with Jang and Begault, renders obvious the highlighting recited in limitation 1[b] and claim 11, including because Pedrotti discloses displaying virtual images at boundaries (*e.g.*, a “virtual fence,” a “grid,” and “other shapes”), and these virtual images can be highlighted (their “brightness ... may increase”) as a user gets closer to the boundaries. *See, e.g.*, Pedrotti (Ex.1005) at 12:66-13:11.

36. Patent Owner does not dispute that Pedrotti discloses highlighting virtual objects at its boundaries, *e.g.*, its virtual fence. Instead, Patent Owner argues that Pedrotti's virtual fence is not an SLP. POR at 6. I disagree.

37. Patent Owner's argument appears to be based on an incorrect, overly narrow view of what constitutes an SLP, which is directly contradicted by the '509 patent, and which persons of ordinary skill in the art would reject. The '509 patent teaches that an SLP is a “location” from which sound is localized, which can be “a point *or area*,” and which can have “a size and/or shape.” '509 patent at 14:58-61 (“This location where the sound was generated relative to the face of the person represents a SLP (i.e., a point or area where sound is localized).”), 37:19-21 (SLP preferences can include, for example, “a size and/or shape of a SLP”). For example,

as Figure 13 of the '509 patent depicts, SLPs can be “square blocks,” i.e., cubes, around a user:



'509 patent (Ex.1001-509) at 28:19-22, Fig. 13. I further note that another of Patent Owner's patents, U.S. Patent No. 10,917,737, characterizes SLPs the same way, providing that “[a] SLP can be a single point ... or a SLP can be a zone or shape or volume or general area.” '737 patent (Ex.1142) at 65:23-31 (“As used herein, a ‘sound localization point’ or ‘SLP’ is a location where a listener localizes sound”; “A SLP can be a single point such as one defined by a single pair of HRTFs or a SLP can be a zone or shape or volume or general area.”).

38. Accordingly, the virtual objects that Pedrotti discloses are displayed at its boundaries, including the virtual fence, are—or at a minimum obviously are—SLPs. For example, Pedrotti's virtual fence, which will be displayed at a particular

location, has a specific size, shape, and area. *See, e.g.*, Pedrotti (Ex.1005) at Figs. 12-14. Pedrotti teaches that its fence can be accompanied by sound, such as an “audio warning.” Pedrotti (Ex.1005) at 15:53-58. And, in view of Jang, or Jang and Begault, persons of ordinary skill in the art would have known and been motivated to have Pedrotti’s fence’s sound be binaural and emanate from the fence, for example, because the directionality of that audio would provide the clearest warning to the user that the user is about to cross the boundary. Accordingly, Pedrotti’s fence is—or at a minimum is obviously—an SLP. And as discussed above, the fence is highlighted when a user approaches it.

39. Additionally, persons of ordinary skill in the art would have understood that the combination of Pedrotti and Jang, and the combination of Pedrotti, Jang, and Begault, teaches, or at a minimum suggests and thus renders obvious, that Pedrotti’s highlighting occurs when a user’s PED is pointed at the SLP—*e.g.*, Pedrotti’s fence. Pedrotti discloses that its boundary images, *e.g.*, the fence, are displayed when “the hand of the user,” which is holding the controller, comes “within a preselected distance of the boundary” and are highlighted when the user “get[s] still closer.” Pedrotti (Ex.1005) at 12:51-13:11, 15:30-32. Skilled artisans would have understood that, in this scenario, the user would be pointing the handheld controller (the PED) at the highlighted boundary image, *e.g.*, the fence. At a minimum, this would have been obvious. Indeed, the handheld controller being pointed at and

moving toward the virtual fence is the most likely action to trigger Pedrotti's highlighting, as users typically (and obviously) hold their controllers pointing away from them, and a controller would have (or at a minimum would obviously have) this orientation as a user moved it toward and got still closer to Pedrotti's boundary, triggering the fence and its highlighting (i.e., the claimed highlighting of an SLP).

40. It also bears repeating that Pedrotti discloses other virtual objects that skilled artisans would have known could be (i) sound-producing, i.e., SLPs, and (ii) highlighted in response to controller pointing, such as "weapon[s]," "sporting implement[s]," and "other toy[s] or device[s]." Pedrotti (Ex.1005) at 9:26-40, 16:33-42. Likewise, Jang discloses several sound-producing virtual objects, such as "avatars, characters, [and] objects," which persons of ordinary skill in the art would have understood to be SLPs. Jang (Ex.1006) at 6:44-47. And Begault also discloses a GUI with icons representing sources of binaural sound, which persons of ordinary skill in the art would have understood to be SLPs. *See* Begault (Ex.1007) at 72, Fig. 5.12. Persons of ordinary skill in the art would have known and been motivated to use Pedrotti's system to point at and then highlight any of these example SLPs with Pedrotti's handheld controllers. As I explained in my opening declaration, such highlighting of sound-producing virtual objects was conventional and was frequently used to facilitate a user pointing at a virtual object or SLP, before the user selected the virtual object or SLP, *e.g.*, to move, interact with, or otherwise control

the virtual object. Op. Decl. ¶¶ 270-271, 274-276. Skilled artisans knew that highlighting provides an important indication that a virtual object was being accurately pointed at, which gives the user essential feedback and confirmation that he or she is pointing at the right object. *See* Op. Decl. ¶¶ 266-268; *see also* Jerald, THE VR BOOK (Ex.1063) at 281 (“Feedback communicates to the user the results of an action or the status of a task, helps to aid understanding of the state of the thing being interacted with, and helps to drive future action. In VR, timely feedback is essential.”).

41. Indeed, in VR, sensory substitution (like highlighting) is and was often used, as touch feedback (*e.g.*, physical manipulation of an object) is not available. *See, e.g.*, Jerald, THE VR BOOK (Ex.1063) at 304 (“Most VR experiences offer little touch feedback, and when they do the feedback is quite limited compared to the sense of touch in the real world.”; “Sensory substitution is the replacement of an ideal sensory cue that is not available with one or more other sensory cues.”). In particular, there is a commonly known problem in VR where the user’s hand may miss or move through a virtual object since there is no physical feedback: “Not having full haptic feedback is more of a problem than just not feeling objects. The hand or other body part (or physical device) continues to move through the object since there is no (or limited) physical force stopping it from doing so. As a result, the physical location of the hand may no longer match the visual location.” Jerald,

THE VR BOOK (Ex.1063) at 304. Persons of ordinary skill in the art would have known that highlighting is one type of sensory substitution that can remedy this type of issue. *See, e.g.,* Jerald, THE VR BOOK (Ex.1063) at 305 (“Highlighting is also used to convey that an object is able to be selected or grabbed when the hand is close even though a collision has not yet occurred.”), Fig. 26.5.

42. This is no different from common principles that have been known in traditional game design, even outside of the VR context. For example, a 2009 article titled *Dora the Explorer: Dora Saves the Farm* discusses applications of game design techniques and describes a game with virtual images with which players interact. Carter (Ex.1148) at 23. The article explains that “[a]s players interact with the screen, the game responds to each user action, such as highlighting the image as players mouse over them, while also providing feedback for positive or negative actions.” Carter (Ex.1148) at 23. As another example, in a 2002 study on the learnability of a software user interface involving an instructional game, *Justice Bao*, researchers noted that “designers have to find ways of making [] clickable objects salient.” Chen (Ex.1149) at 396. For example, games can “highlight[]” objects that are moused over, “so that clickable objects are distinctly noticeable from other contextual objects.” Chen (Ex.1149) at 396-397. In other words, feedback provided through highlighting ensures that a user is not left guessing at what virtual object he or she is pointing at, and ensures that the user is not left continuously clicking or

futilely attempting to select a particular virtual object. Indeed, the highlighting of items in graphical user interfaces (GUIs) is a basic practice that dates back to at least the 1980s. For example, in a 1986 paper titled “Designing menu selection systems,” Ben Shneiderman wrote: “There is a great sense of satisfaction in being able to move the cursor around the screen; *the menu item is highlighted clearly on the screen* and in the user’s mind, and screen space is conserved since item numbers are not needed. In fact, *highlighting*, underscoring, boxes, pointers, color, or inverse video can be used to *visually indicate the item that has been selected.*” Shneiderman (Ex.1156) at 68.

43. Skilled artisans would have understood Pedrotti with the benefit of knowledge of these types of fundamental design techniques, and Pedrotti discloses the exact types of interactions in which the highlighting of virtual objects (and SLPs) would have been advantageous (and obvious). For example, Pedrotti teaches: “In a conventional video game, for example, a user may use a controller to have a character on a television screen ‘pick up’ a weapon displayed on the screen. Similarly, with the present approach the processor can cause a HMD to display a virtual weapon while the user is in a virtual world. Then, upon the user’s extending his or her physical hand(s) in such a way as to cause the corresponding virtual hand(s) to ‘reach for’ the displayed virtual weapon and the user’s activating a proper command (*e.g.*, by pressing a button on the controller), the processor can cause the

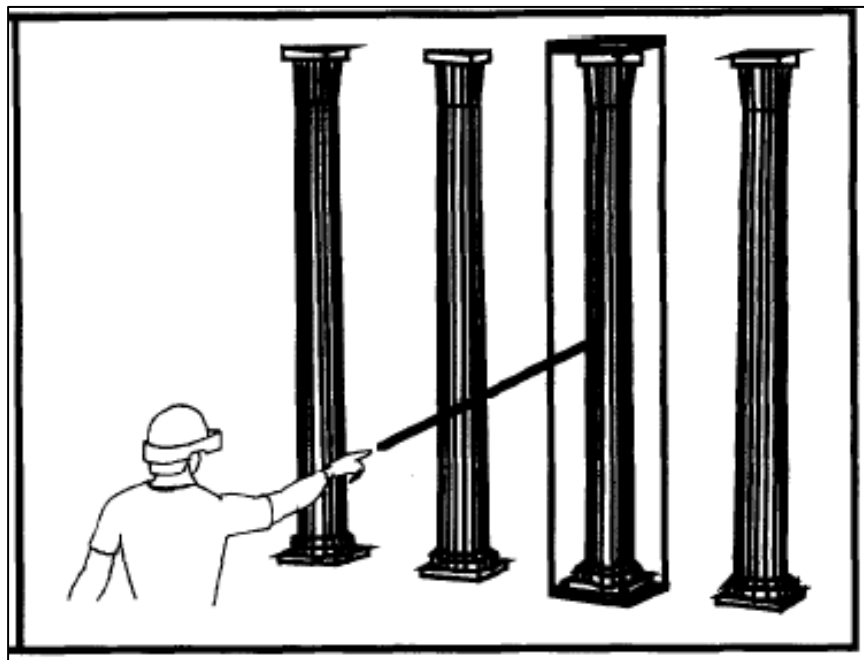
HMD to display the user's virtual hand(s) 214 as 'picking up' and holding that virtual weapon." Pedrotti (Ex.1005) at 9:26-40. Persons of ordinary skill in the art would have known and been motivated to use highlighting in this scenario—*e.g.*, to highlight the target virtual weapon the user is pointing at before it is picked up—to provide the user an advantageous visual indication that the user is actually pointing at the weapon he or she wants.

44. Patent Owner argues that Pedrotti's interactive virtual objects are merely "virtual representation[s] of the controller[s]." POR at 7. But Patent Owner misunderstands Pedrotti's disclosures, including the example from Pedrotti discussed immediately above, in which a target virtual object (*e.g.*, a virtual gun or sword) is first displayed before it is picked up. In any case, even if Patent Owner were right about this example (to be clear, Patent Owner is wrong), Pedrotti nevertheless teaches, or at a minimum renders obvious, using its controllers to point at and interact with other virtual objects and SLPs, which would obviously be highlighted as claimed. For example, it would have been obvious to persons of ordinary skill in the art that a user, after picking up Pedrotti's virtual sword or virtual gun, can still use the controller (now shown in VR as a sword or gun) to point at and interact with other moveable virtual objects. A simple example is if the user aims the controller (now depicted as a gun) at a target; it would have been obvious to

highlight the virtual target at which the gun is pointing in order to convey to the user where the gun is aimed, *e.g.*, before the user shoots the gun.

45. Multiple additional references that I discussed in my opening declaration confirm that skilled artisans reading Pedrotti would have known and been motivated to use highlighting in Pedrotti's system, as claimed, including in view of Jang, or in view of Jang and Begault, as I have described above.

46. For example, Mine ISAAC depicts a column that is highlighted by a box to facilitate its selection:



Mine ISAAC (Ex.1115) at Fig. 1 (excerpted). Mine ISAAC explains that “[d]uring AAAD [‘action-at-a-distance’] interaction, you select objects using a laser beam emanating from your hand.” Mine ISAAC (Ex.1115) at 548-49.

47. As another example, Mine Exploiting Proprioception 1997 explains that virtual objects can be “selected with a spotlight” and “manipulated using extender grab.” Mine Exploiting Proprioception 1997 (Ex.1116) at 80-82. As shown below, the target virtual objects (a cow, below) are highlighted when the user wearing the HMD points a controller at them to select and then manipulate them.



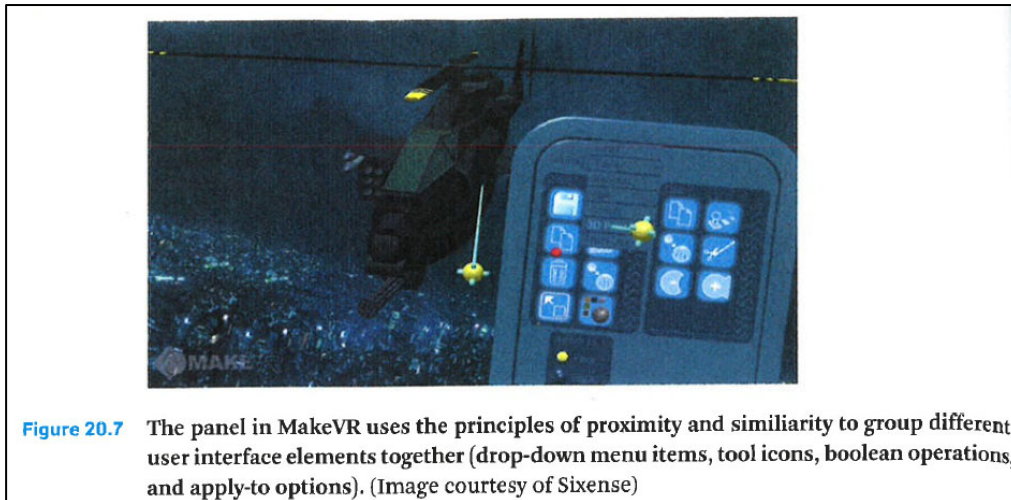
Mine Exploiting Proprioception 1997 (Ex.1116) at Fig. 6.1.

48. As another example, Figure 12 from one of my own publications, Welch, *No Silver Bullet*, shows a user wearing an HMD and pointing a controller at a highlighted menu item.

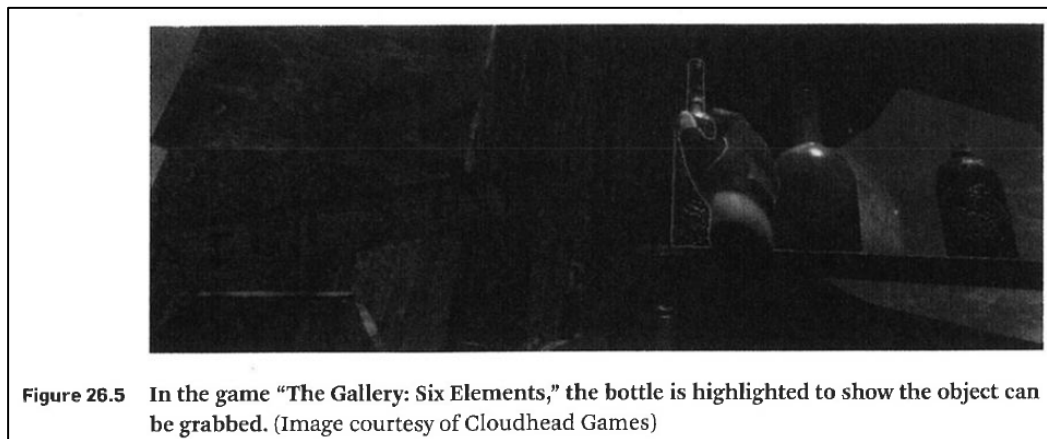


Welch, *No Silver Bullet* (Ex.1135) at Fig. 12; 34 (“Figure 12 shows some of the tracked devices and the wireless links that [were] developed” for “Head-and-hand tracking”).

49. As another example, as I noted above, Jerald, *THE VR BOOK* explains that “highlighting is [] used to convey that an object is able to be selected.” Jerald, *THE VR BOOK* (Ex.1063) at 305; *see also* Jerald, *THE VR BOOK* (Ex.1063) at 327 (“The Pointing Pattern is one of the most fundamental and often-used patterns for selection. The Pointing Pattern extends a ray into the distance and the first object intersected can then be selected via a user-controlled trigger.”). And Jerald, *THE VR BOOK* depicts such highlighting in at least the following figures:



Jerald, THE VR BOOK (Ex.1063) at Fig. 20.7.



Jerald, THE VR BOOK (Ex.1063) at Fig. 26.5.

(2) Patent Owner's Arguments About Jang are Misplaced and Incorrect

50. In addition to the arguments Patent Owner advances about Pedrotti's disclosures, which are wrong for reasons discussed above, Patent Owner argues that the combination of Pedrotti and Jang does not teach or suggest highlighting of an SLP because "Jang does not disclose anything regarding the selection or emphasis

of images associated with the sounds from [its] focus area or [its] non-focus area.”

POR at 6. I disagree.

51. As I explained in my opening declaration, Jang discloses a system that allows a user to designate “priorities of sound sources” in a virtual environment, and further discloses that a user may interact with his or her virtual environment. Jang (Ex.1006) at Abstract, 11:3-8 (describing “space shift” from one virtual environment to another, and “priorities of the sound sources of a focus area and non-focus areas”) 6:35-38 (“For example, a user may interact with the virtual environment using an avatar. The user may see, hear, and otherwise sense the virtual environment from the perspective of the avatar.”); *see also* Op. Decl. §IX.B (Overview of Jang). As I also explained in my opening declaration, Jang discloses that “each divided focus or non-focus area may contain any number of virtual objects represented by sensory data that may include audio and visual data.” Op. Decl. ¶ 168; *see also* Jang (Ex.1006) at 8:43-46. Persons of ordinary skill in the art thus would have understood that Jang teaches or at a minimum suggests and renders obvious the selection and emphasis of images associated with sound sources, *e.g.*, virtual objects, in its interactive virtual environment.

52. I further explained in my opening declaration that, in combination with Pedrotti, persons of ordinary skill in the art would have known and been motivated to use Pedrotti’s controller to point at and select an image of a pep band in Jang’s

virtual basketball court associated with the pep band's sound or a conference attendee in Jang's virtual conference room. That sound source (*e.g.*, the pep band or conference attended) would obviously be highlighted when pointed at, consistent with Pedrotti's teachings, before being moved from one location (a first SLP) to a different location in auditory space in the virtual environment (a second SLP). *See* Op. Decl. ¶ 276. Indeed, Jang discloses that its techniques are applicable to games such as "Second Life": "[I]n a virtual environment, a user can shift between virtual spaces without having to portray the passage of distance or time to travel from one space to another. An example of such a virtual reality system includes a virtual reality game, 'Second Life,' developed by LindenLab of the United States." Jang (Ex.1006) at 1:65-67; *see* Op. Decl. ¶ 216. As I previously explained, persons of ordinary skill in the art would have known that a game such as "Second Life" could be played on HMDs such as the Oculus Rift or the HMD described in Pedrotti, and that Pedrotti and Jang in combination teach interactions with virtual objects, including pointing at, selecting, moving, and highlighting those objects, which were all used in Second Life. *See* Op. Decl. ¶ 216. As additional support for this point, I cited to a video, *How to Use Oculus Rift with Second Life*, YOUTUBE.COM (May 22, 2014), <https://www.youtube.com/watch?v=TLL5JVwG118> (Ex.1163 and Ex.1164), which provides a demonstration of Second Life on an HMD. *See* Op. Decl. ¶ 216. As indicated by the still image from that video shown below, there are many virtual

objects in a Second Life virtual environment with which a user can interact, including chairs, a fire, and boxes.



How to Use Oculus Rift with Second Life, YOUTUBE.COM (May 22, 2014), <https://www.youtube.com/watch?v=TLL5JVwG118> (Ex.1163 and Ex.1164) at 1:16-1:20 (narration explaining that the user is able “interact with objects and the user interface, or UI for short”).

53. I have also explained, including in a declaration about which Patent Owner’s counsel questioned me at my deposition for this *inter partes* review, that Jang’s reference to “Second Life” would have indicated to persons of ordinary skill in the art that users of Jang’s system would have been able to manipulate sound-producing virtual objects in Jang’s system. Jang (Ex.1006) at 1:65-67. This is because in Second Life, including in its “immersive, VR experience,” users

interacted with, among other things, other users using avatars that speak. *See, e.g.,* Second Life Community (Ex.1089) at 1 (describing Second Life’s beta test with the Oculus Rift headset); Stuart Dredge, *Virtual World Second Life to Be Reincarnated, with Oculus Rift*, *The Guardian* (June 24, 2014), <https://www.theguardian.com/technology/2014/jun/24/second-life-oculus-rift-virtual-world> (Ex.1095) (explaining that users still interacted in this manner in the VR integration); *see also* Ex. 1143, Welch Dep., Ex. 3, Declaration of Dr. Gregory Welch in Support of Petition for Inter Partes Review of U.S. Patent No. 10,917,737, ¶ 250; *see also, e.g.,* Welch Dep. Tr. (Ex.2012) at 30:8-15.

54. Furthermore, additional information about Second Life, including information in the official guide for Second Life and videos available on a compact disc accompanying the guide, demonstrate why Jang, with its reference to Second Life, does, in fact, suggest to persons of ordinary skill in the art “the selection [and] emphasis,” including highlighting, “of images associated with [] sounds,” contrary to what Patent Owner argues (POR at 6).

55. For example, Second Life: The Official Guide describes the selection of “prims” (virtual objects comprising geometric primitives) and that different highlighting for linked and unlinked prims will cause changes to the highlighting:

When you've selected all the prims you wish to link, link them by selecting Link from the Tools menu or using the keyboard command Control-L (Figure 7.8).

See how the highlight changed on your collection of prims? This means that it's now a linked object. The last prim you selected is now highlighted in yellow, indicating that it's become the parent (or root) prim. The prims highlighted in white are called the child prims. They're all now part of the same object. By deselecting the object and then reselecting it, you can see that all the prims are still highlighted in yellow and white. You can move the entire object around just as if it were a single prim (Figure 7.9).

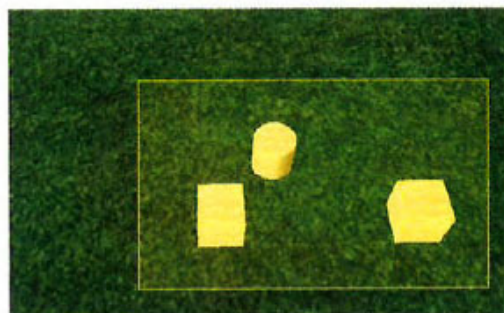


Figure 7.7: Multiple prims selected in a selection box

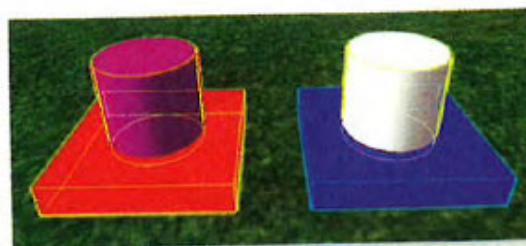


Figure 7.9: Comparison of the selection halo on linked and unlinked prims

Second Life: The Official Guide (Ex.1151) at 146-147, 10 (describing prims as “solids (3D geometric shapes) that create almost all the objects in *Second Life*”); see also Second Life: The Official Guide (Ex.1151) at 147, Fig. 7.10 (discussing scaling a virtual object by changing its dimensions, and showing that highlighting is used to facilitate manipulation of the object to be scaled).

56. As another example, Second Life: The Official Guide shows that highlighting was used with user interfaces in Second Life, *e.g.*, to identify what a user is pointing at, to facilitate selection:

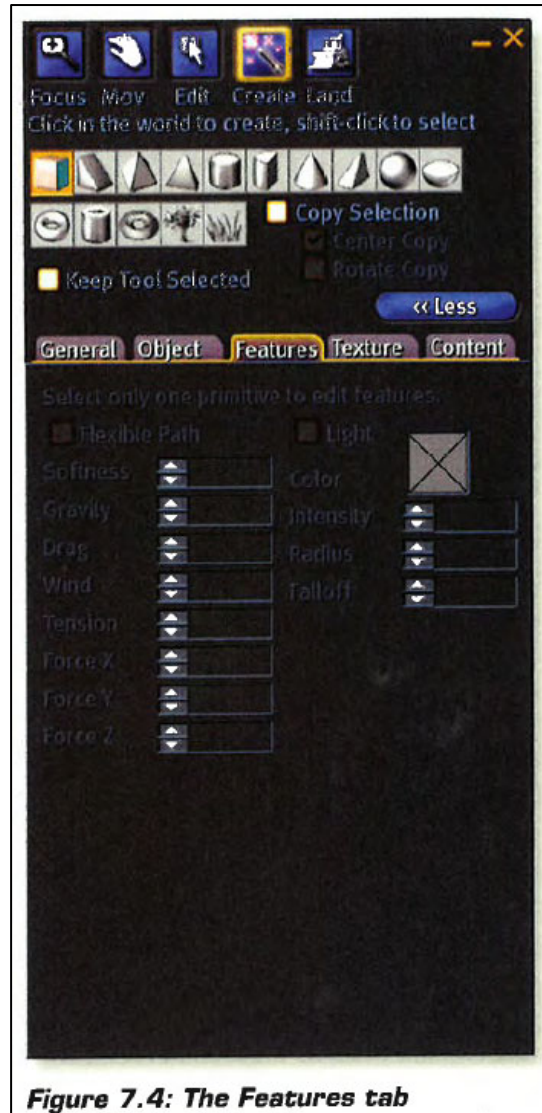


Figure 7.4: The Features tab

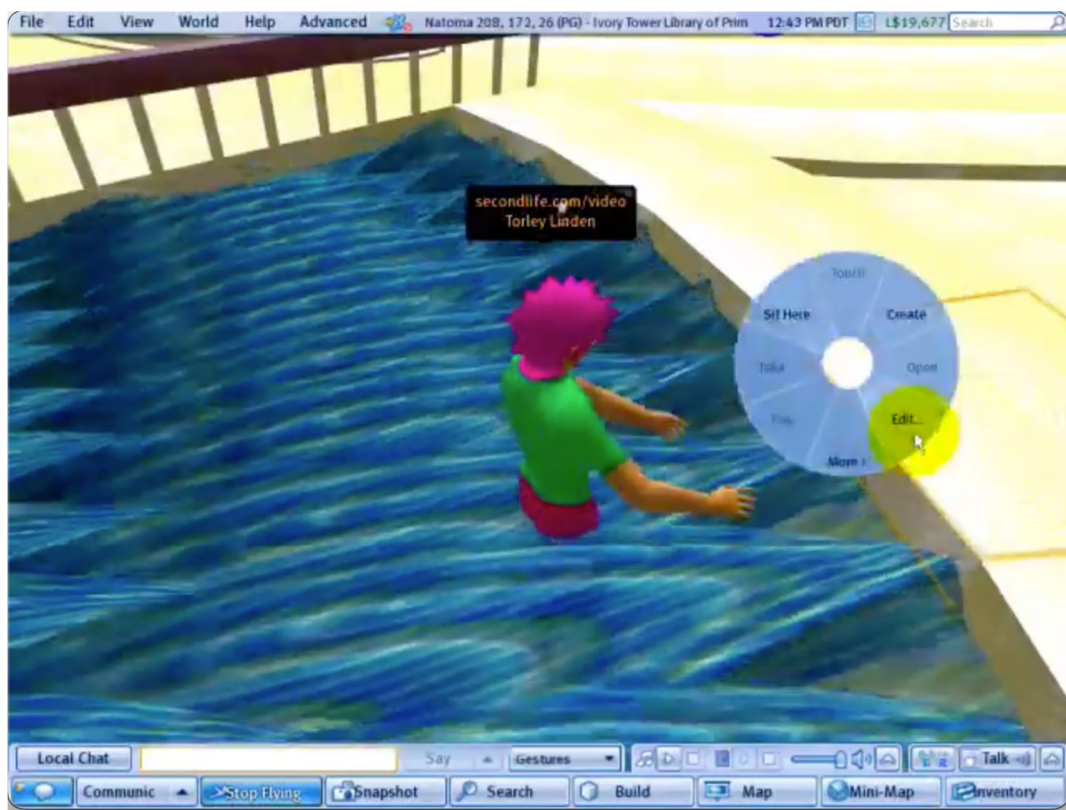
Second Life: The Official Guide (Ex.1151) at 141, Fig. 7.4 (excerpt) (showing highlighting around target menu items).



Second Life: The Official Guide (Ex.1151) at 145, Fig. 7.8 (excerpt) (gray highlighting on target menu item “Link” near the middle).

57. As another example, in a video about how to “[t]urn off annoying UI sounds” in Second Life, the user clicks to open a pie menu, and then points to different menu options (different sections of the pie). As the user points to each available menu option corresponding to a different section of the pie, the section that is pointed at by the user is highlighted (it changes to a lighter shade of gray) and the

system simultaneously plays a clicking and item-specific tonal sound as shown below:



Turn off annoying UI sounds - Second Life Video Tutorial, YOUTUBE.COM (May 28, 2008), <https://www.youtube.com/watch?v=B2DpZRQETK0> (Ex.1165 and Ex.1166) at 1:20-1:24. Both the highlighting and corresponding sound provide feedback to the user.

58. The Second Life pie menu itself is explained in *Second Life: The Official Guide*:



***Figure 7.1: The pie menu
when you're clicking on an
object***

Second Life: The Official Guide (Ex.1151) at 136, Fig. 7.1.

59. The official Second Life Wiki includes a table that lists “sounds built in to Second Life,” which includes seven different sounds associated with “pie menu slice highlight” items (pie menu slice highlight1 – pie menu slice highlight7):

Client sounds

From Second Life Wiki

Second Life Wiki > Client sounds

This is a listing of the sounds built into Second Life.

Sound Name 	UUID Key 	Description 	Filename 
bell ting	ed124764-705d-d497-167a-182cd9fa2e6c		
click	4c8c3c77-de8d-bde2-b9b8-32635e0fd4a6		
health reduction (female)	219c5d93-6c09-31c5-fb3f-c5fe7495c115		
health reduction (male)	e057c244-5768-1056-c37e-1537454eeb62		
IM session, new incoming	67cc2844-00f3-2b3c-b991-6418d01e1bb7	(2 bells)	
IM start	c825dfbc-9827-7e02-6507-3713d18916c1		
instant message notification	67cc2844-00f3-2b3c-b991-6418d01e1bb7		
invalid operation	4174f859-0d3d-c517-c424-72923dc21f65		
keyboard loop	5e191c7b-8996-9ced-a177-b2ac32bfea06		
money increase	77a018af-098e-c037-51a6-178f05877c6f	(coins)	
money reduction	104974e3-dfda-428b-99ee-b0d4e748d3a3	(cash register bell)	
null keystroke	2ca849ba-2885-4bc3-90ef-d4987a5b983a		
object collision	be582e5d-b123-41a2-a150-454c39e961c8		
object collision	212b6d1e-8d9c-4986-b3aa-f3c6df8d987d	(rubber)	
object collision	d55c7f3c-e1c3-4ddc-9eff-9ef805d9190e	(plastic)	
object collision	2d8c6f51-149e-4e23-8413-93a379b42b67	(flesh)	
object collision	6f00669f-15e0-4793-a63e-c03f62fee43a	(wood splintering?)	
object collision	85cda060-b393-48e6-81c8-2cfdfb275351	(glass break)	
object collision	d1375446-1c4d-470b-9135-30132433b678	(metal clunk)	
object create	3c8fc726-1fd6-862d-fa01-16c5b2568db6	(whoosh)	
object delete	0cb7b00a-4c10-6948-84de-a93c09af2ba9	(shake)	
object rez	f4a0660f-5446-dea2-80b7-6482a082803c		
pie menu appear	8eaed61f-92ff-6485-de83-4dcc938a478e	(ding)	
pie menu slice highlight	d9f73cf8-17b4-6f7a-1565-7951226c305d		
pie menu slice highlight1	f6ba9816-dcaf-f755-7b67-51b31b6233e5	(same as above)	
pie menu slice highlight2	7aff2265-d05b-8b72-63c7-dbf96dc2f21f	(same as above)	
pie menu slice highlight3	09b2184e-8601-44e2-afbb-ce37434b8ba1	(same as above)	
pie menu slice highlight4	bbe4c7fc-7044-b05e-7b89-36924a67593c	(same as above)	
pie menu slice highlight5	d166039b-b4f5-c2ec-4911-c85c727b016c	(same as above)	
pie menu slice highlight6	242af82b-43c2-9a3b-e108-3b0c7e384981	(same as above)	
pie menu slice highlight7	c1f334fb-a5be-8fe7-22b3-29631c21cf0b	(same as above)	

Ground 1

Claims 1-14 and 17-20 Would Have Been Obvious
Over Pedrotti and Jang, and Over Pedrotti, Jang, and
Begault

Client sounds, SECOND LIFE WIKI (May 9, 2012),

http://wiki.secondlife.com/wiki/Client_sounds

[<https://web.archive.org/web/20120509175157/>] (Ex.1159) (highlighting added).

60. As another example, in a video demonstrating how to build a bridge in Second Life, a user controls an avatar and points a cursor (shown in black on the left edge of the large wooden cylinder in front of the avatar) at virtual objects on the screen (below, the pieces of virtual wood to be used for the virtual bridge).



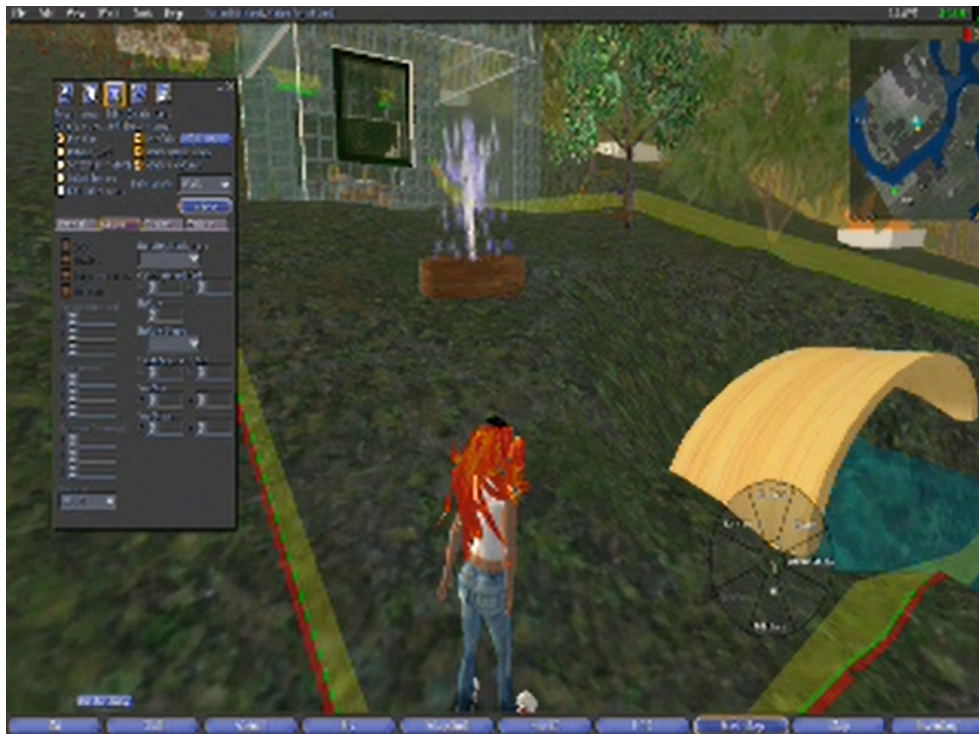
Second Life: The Official Guide, Basic Building Demonstration (Ex.1152 and Ex.1153) at 03:25.

61. When the user points at objects, including target virtual objects and menu items, highlighting is used to facilitate the user's selection and manipulation of those objects, as shown below. Note the yellow glowing ring around the edge of the large wooden cylinder in front of the avatar.



Second Life: The Official Guide, Basic Building Demonstration (Ex.1152 and Ex.1153) at 03:30.

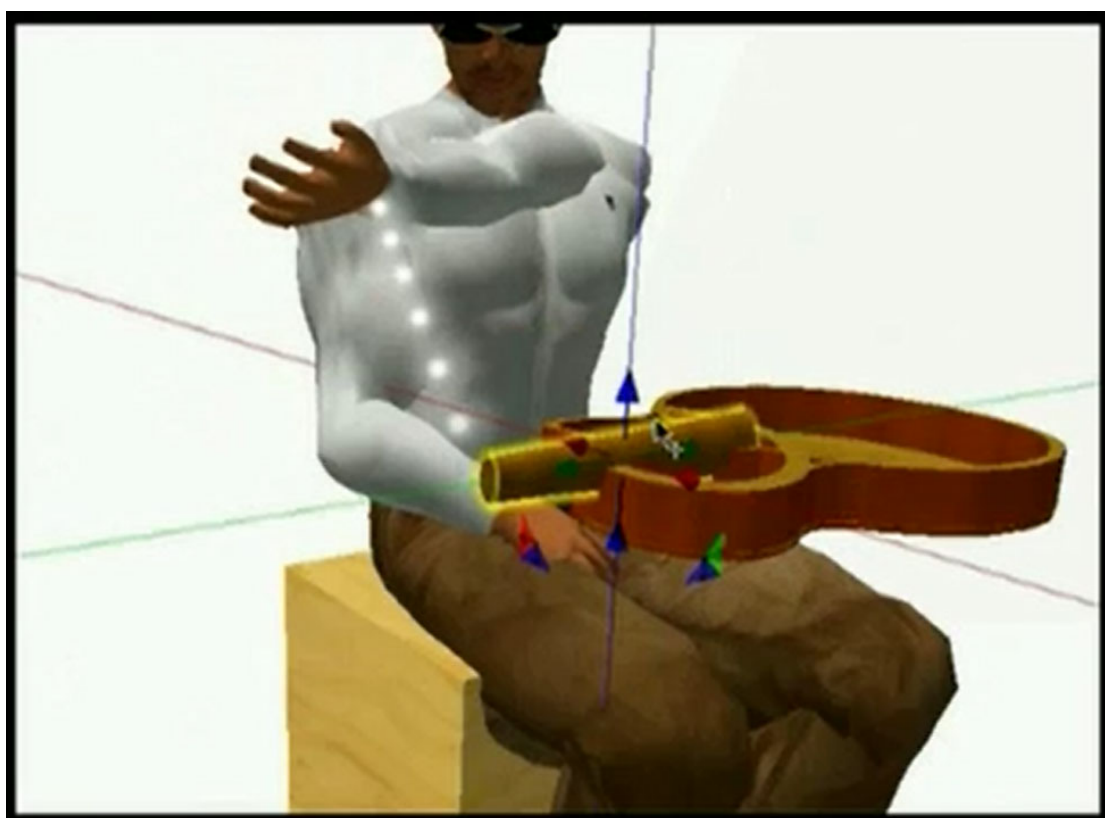
62. The virtual objects in the user's environment, including sound-producing virtual objects, *e.g.*, the virtual water fountain shown below, can be manipulated this way, through pointing and highlighting indicating accurate pointing before selection. Indeed, in the same video discussed above, the user even manipulates the ground level of her virtual environment, *i.e.*, the ground on which the sound-producing virtual fountain sits. And as shown below, to facilitate that interaction, the land surrounding the sound-producing fountain is highlighted.



Second Life: The Official Guide, Basic Building Demonstration (Ex.1152 and Ex.1153) at 06:25.

63. As another example, another video that accompanied Second Life: The Official Guide, which indicates at its conclusion that it was created in 2006,

demonstrates a user in Second Life building a virtual guitar. Second Life: The Official Guide, Suzanne's Guitar (Ex.1154 and Ex.1155). The user points a mouse cursor (shown in black) at the virtual objects on the screen and interacts with and manipulates them to build the guitar. As shown below, target objects (*e.g.*, neck of the guitar) are highlighted in response to the user's pointing, to facilitate such interaction and manipulation.



Second Life: The Official Guide, Suzanne's Guitar (Ex.1154 and Ex.1155) at 00:47.

I also note that this is just one example of the highlighting in response to pointing that frequently occurs in this video.

64. These examples demonstrate that, consistent with and in view of Jang’s disclosures, persons of ordinary skill in the art would have known and been motivated to use highlighting (and sound) in response to pointing, to facilitate interactions with sound-producing virtual objects in the virtual environments to which Pedrotti and Jang are directed, such as Second Life.

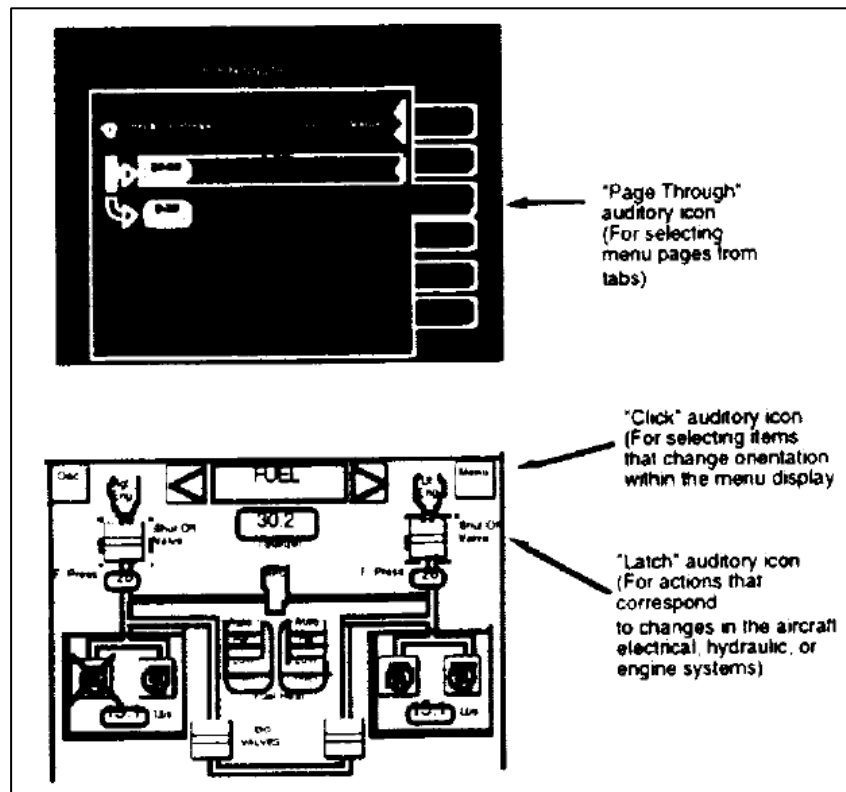
(3) Patent Owner’s Argument About Begault is Misplaced and Incorrect

65. In addition to the arguments Patent Owner advances about Pedrotti’s and Jang’s disclosures, which are wrong for reasons discussed above, Patent Owner argues that “Begault simply provides a user interface that enables configuration of sound sources for subsequent received sound.” POR at 11. I disagree.

66. As I explained in my opening declaration, persons of ordinary skill in the art would have been motivated to use Pedrotti’s controllers to interact with and arrange the SLPs that Begault discloses can be controlled and manipulated by a user—Begault’s “sound inputs in virtual auditory space”—including through use of the GUI that Begault discloses for such interactions, to provide some form of dynamic visual confirmation that a user’s moving hand is sufficiently pointing at (intersecting) the target virtual image. Op. Decl. ¶ 277; Begault (Ex.1007) at 172-173, Fig. 5.12. And it would have been obvious to highlight SLPs in such interfaces when they were pointed at. Op. Decl. ¶ 278. This type of highlighting in response

to pointing, as a user navigates a menu or other interface, like Begault's Figure 5.12 GUI, was routine.

67. Indeed, Begault discloses a menu display that shows highlighting used to distinguish selectable items. Specifically, the top image reproduced below shows a box used to highlight a tab the user can select:

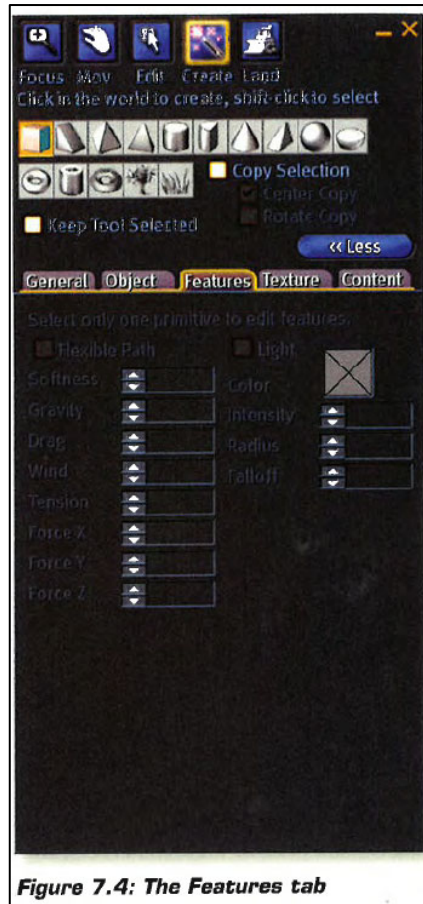
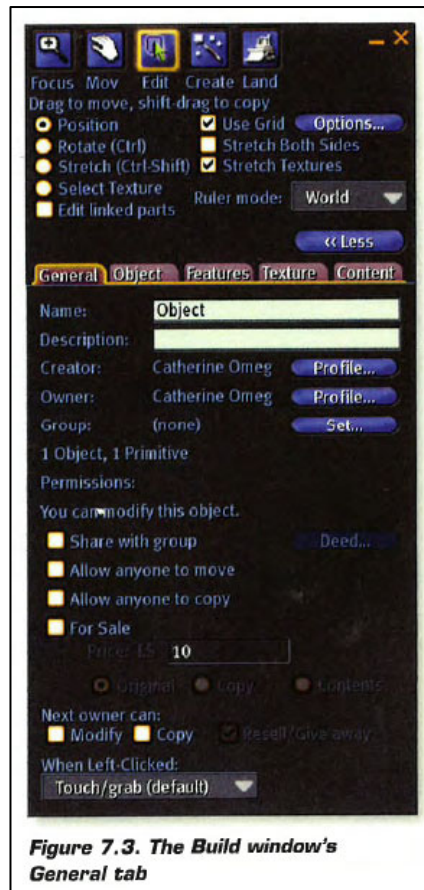


Begault (Ex.1007) at 159, Fig. 5.1.³

³ I note that the above-reproduced Figure 5.1 from Begault also shows that Begault discloses using spatialized audio, *e.g.*, "Click" noises, for navigating menu pages, but I discuss this in more detail in the context of limitation 1[d] and claim 10 below.

68. Furthermore, it was well-known to persons of ordinary skill in the art that selectable menu items could be highlighted to help users know where they were pointing, to facilitate selection. As I discuss above, Ben Shneiderman teaches this in his 1986 paper “Designing menu selection systems.” *See, e.g.*, Shneiderman (Ex.1156) at 68; *see also* Shneiderman (Ex.1156) at 59, 60, Fig. 1. In addition, the Second Life videos I discussed above show and the following images further confirm:





Second Life: The Official Guide (Ex.1151) at 136, 139, 141, Figs. 7.2-7.4.

* * *

69. For the reasons set out above and in my opening declaration, it is my opinion that Pedrotti in view of Jang, and Pedrotti in view of Jang and Begault, teach and render obvious limitation 1[c] and claim 11. Also, it is my opinion that even if the Ground 1 prior art was “silent” with respect to highlighting—which Patent Owner argues, but which is not true—the highlighting recited in limitation 1[c] and claim 11 still would have been obvious to skilled artisans given how conventional this practice was in computer games and virtual reality applications. Limitation 1[c]

and claim 11 do not recite anything more than the application of a conventional, well-known technique that was within the general knowledge of skilled artisans, as I demonstrated above.

b. Limitation 1[d] and Claim 10: Playing a Binaural Sound In Response to Pointing at SLP

70. Limitation 1[d] recites: “playing, with the WED worn on the head of the user, the binaural sound that emanates from the one of the multiple SLPs in response to the one of the multiple SLPs being pointed at by the PED held in the hand of the user.” ’509 patent (Ex.1001-509) at cl. 1. Limitation 10[b] recites: “playing the binaural sound that originates from the one of the SLPs in the zone in response to the WED determining that the PED is pointed at the one of the SLPs.” *See* ’509 patent (Ex.1001-509) at cl. 10 (emphasis added).

71. Patent Owner does not dispute that the Ground 1 art renders obvious a WED worn on the head of the user that plays binaural sound from an SLP. Rather, Patent Owner argues that the Ground 1 art fails to disclose or suggest that this occurs “in response to” a PED being pointed at an SLP. POR at 10. I disagree.

72. As I explained above, the virtual objects at Pedrotti’s boundaries, *e.g.*, Pedrotti’s virtual fence, are, or obviously are, SLPs. *See* ¶¶ 35-40. As noted, Pedrotti teaches that with the display of such virtual objects “it may again be appropriate to generate an audio warning as well.” *See* Pedrotti (Ex.1005) at 15:53-

58 (“Also as above, in various embodiments, the processor can generate the visual warning in the form of grid lines or a virtual fence, or in any other desired shape or configuration. In some embodiments, it may again be appropriate to generate an audio warning as well, or instead of, the visual warning.”). And, for reasons discussed, skilled artisans would have understood that Pedrotti’s system generates contemporaneous visual and audio warnings when, and in response to, a user pointing at Pedrotti’s boundary image SLPs—for example, in response to the user’s controller extending toward and getting still closer to the fence. Consistent with Pedrotti’s teachings, in response to the user pointing his or her controller at Pedrotti’s fence, which is an SLP, the fence would be highlighted and play an audio warning, the latter of which would obviously be binaural in view of Jang or in view of Jang and Begault.

73. Indeed, I note that, to skilled artisans, coupling the display of Pedrotti’s fence with its sound, as Pedrotti teaches, would have been a straightforward implementation of the concept of binding, which was commonly used in the design of virtual environments. Binding refers to conveying “multimodal events as coming from a single entity,” and it was known to be “especially important for maximizing intuitive VR interactions.” Jerald, *THE VR BOOK* (Ex.1063) at 72-73. Thus, persons of ordinary skill in the art would have known and been motivated to both highlight

Pedrotti's fence and play the fence's audio warning in response to the user pointing the controller at the fence's SLP, as described above.

74. Begault further confirms the obviousness of the claimed binaural sound playback, as Begault discloses playing a warning sound to alert the user that he or she is approaching or crossing a boundary: "In virtual reality, one can walk through walls and objects; but by activating auditory information in the form of a bumping or crashing sound, the user receives feedback that a particular physical boundary has been violated." Begault (Ex.1007) at 171. This disclosure is precisely aligned with how persons of ordinary skill in the art would have understood Pedrotti's boundary images, including the virtual fence, operate.

75. Persons of ordinary skill would consider contemporaneous visual and aural warnings to be essential, as the user might not even see the visual indication of a boundary incursion, *e.g.*, because the user is looking in another direction as they step into a boundary region. Such multimodal feedback, including even vibrations, is exceedingly common. For example, "[i]n fully immersive VR simulations, part (or all) of the object of interest may not be in the user's field of view" and so "[i]n such instances, it is necessary to provide a sound queue [cue] as to where the object is (*e.g.*, a ball bouncing on the floor)." *See* Burdea (Ex.1147) at 10-11. As Burdea states, this is especially applicable to VR environments, such as Pedrotti's. Moreover, Burdea recognizes the need for "3-D audio localization" of sound,

processed through HRTFs, in these “fully immersive VR simulations.” *See* Burdea (Ex.1147) at 11; *see also* Wenzel 1992 (Ex.1158) at 81 (“Often the only modalities available for interacting with complex information systems have been visual and manual. Many investigators, however, have pointed out the importance of the auditory system as an alternative or supplementary information channel”); Begault 1993 (Ex.1146) at 361 (discussing the “development of a three-dimensional (3D) interactive display,” whose applications include “telepresence applications” and “shared electronic workspaces”).

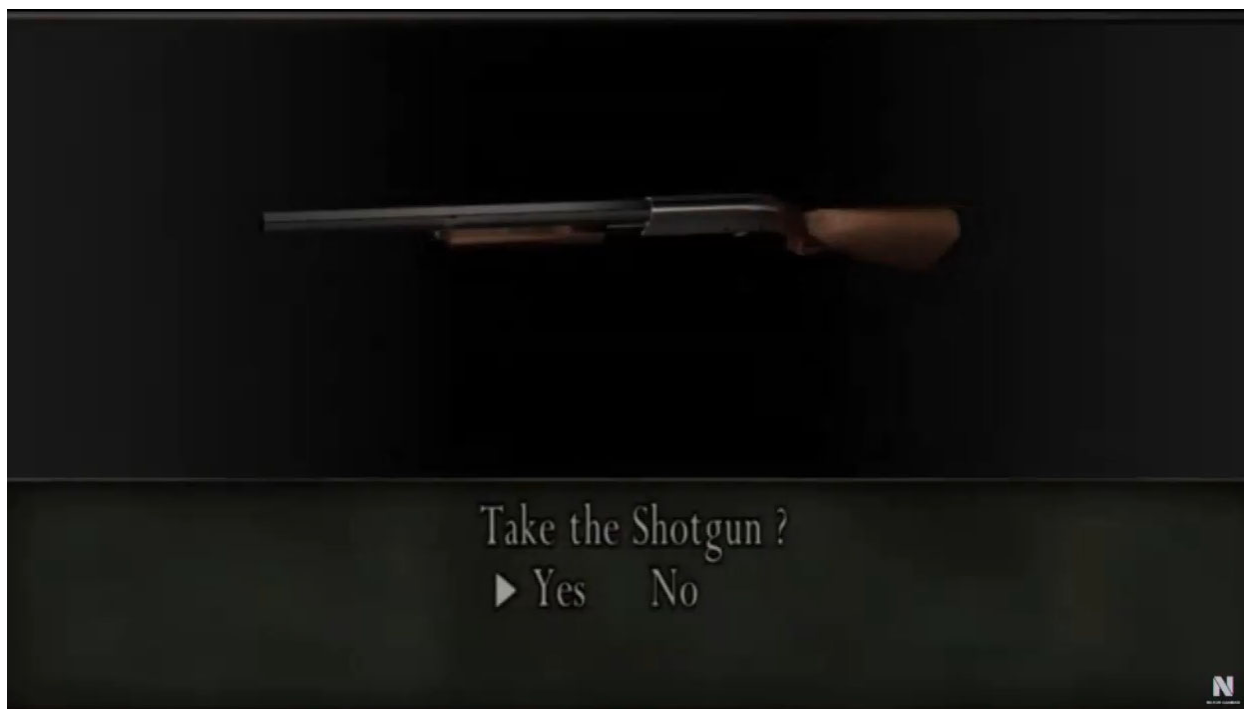
76. I further note that persons of ordinary skill in the art would have understood that the boundary images that are displayed by Pedrotti and accompanied by sounds are not limited to just Pedrotti’s fence (or a grid). As noted, Pedrotti teaches that “other shapes” can be used. Pedrotti (Ex.1005) at 12:66-13:11. Skilled artisans would have known that Pedrotti’s “other shapes” could be many different types of sound-producing virtual objects. For example, Pedrotti’s system could be implemented with a well-known hummingbird distractor (*see* Op. Decl. ¶ 138 (reproducing same)) or something as straightforward as a stop sign. And any such virtual objects could likewise be highlighted and produce binaural sound playback (*e.g.*, a chirping noise or a warning beep or the word “stop”) in response to a user extending his or her controller toward and thus pointing at (or obviously pointed at) these objects.

77. Additionally, as I explained in my opening declaration, skilled artisans would have known and been motivated to use binaural sound playback, as claimed, to facilitate interactions with, and selection of, the many other types of sound-producing virtual objects disclosed by Pedrotti, Jang, and Begault. Op. Decl. ¶¶ 280-289. For example, taking Pedrotti's disclosed examples of picking up virtual objects (e.g., "gun, sword or other weapon"), it would have been obvious to persons of ordinary skill in the art that pointing at those virtual objects, e.g., to select them to be picked up, would be accompanied by a corresponding sound. For instance, if the user wanted to pick up the virtual gun from an armory, he or she could point at it and, in response, the system would obviously play a corresponding gun loading sound. Or the system could play a sound of a slashing sword if the user pointed at the virtual sword. Or the system could play the buzz of a lightsaber if the user pointed at a lightsaber. Such sound effects were common in video games and computer games, including in VR, prior to February 2016. For example, in the popular DooM and DooM2 games, specific sounds were played in relation to a "selection" action for a particular weapon, such as the chainsaw. *See, e.g., List of DooM2 Sounds*, DOOM WORLD (July 28, 2001), <https://www.doomworld.com/forum/topic/1352-list-of-doom2-sounds/> (Ex.1160) (referring to "DSSAWUP=Chainsaw select sound" and "DSWPNUP=Pick up weapon sound"); *Music and Sounds*, OLDDOOM.COM (Mar. 31, 2012),

<http://www.wolfensteingoodies.com/archives/olddoom/music.htm>

[<https://web.archive.org/web/20120331103727/>] (Ex.1161) (providing the .wav file for the “Selected” sound associated with “Chainsaw,” listed under “Weapons”). As another example, in Resident Evil 4 for PC, a game that was available in 2005 (*Resident Evil 4*, WIKIPEDIA.ORG, https://en.wikipedia.org/wiki/Resident_Evil_4 (last visited Aug. 7, 2024) (Ex.1162)), a cocking gun sound effect plays to indicate that a shotgun has been selected by and “taken” by the user as part of the user’s inventory. This sound effect plays after the user’s character has walked up to and selected the shotgun.





Excerpt of *Chapter 1-1 | Resident Evil 4 (2005) | PC | No Commentary Walkthrough*
& *Gameplay 1*, YOUTUBE.COM (Feb. 27, 2023),

https://www.youtube.com/watch?v=S1si4op6_6A (Ex.1167 and Ex.1168) at 0:04-0:06 (at 21:34-21:36 in original video). Similarly, while the user is organizing the inventory in their attaché case, as indicated by the yellow, highlighted selection rectangle that moves over to different items, a “whoosh” sound effect plays as this rectangle is directed over each item to which the user points. When the user has chosen a particular item, a “click” sound effect plays to indicate the selection of an item to be moved or repositioned in the attaché case. When “Handgun Ammo” is rotated there is a distinct weapon cocking sound, and items are placed into their final position there is a “locking” sound.







Excerpt of *Chapter 1-1 | Resident Evil 4 (2005) | PC | No Commentary Walkthrough & Gameplay 1*, YOUTUBE.COM (Feb. 27, 2023), https://www.youtube.com/watch?v=S1si4op6_6A (Ex.1167 and Ex.1168) at 1:04-1:08 (at 22:35-22:39 in original video). In another instance, when the user is exploring a menu of options to “Sell,” “Buy,” or “Tune Up” his inventory, a “click” sound effect plays at the same time the option is highlighted for selection as the user navigates and points to each of those options.



Excerpt of *Chapter 1-2 | Resident Evil 4 (2005) | PC | No Commentary Walkthrough*
& *Gameplay* 2, YOUTUBE.COM (Feb. 28, 2008),
<https://www.youtube.com/watch?v=PS5a6bVMHxw> (Ex.1169 and Ex.1170) at

0:12-0:14 (at 4:47-4:49 in original video). As the user scrolls through the list of items in the inventory to sell, a “whoosh” sound effect plays at the same time the listed item is highlighted for selection as the user moves over each of those options. And, a chime sound effect plays at the time the user selects the highlighted item to sell.





Excerpt of *Chapter 1-2 | Resident Evil 4 (2005) | PC | No Commentary Walkthrough*

& *Gameplay* 2, YOUTUBE.COM (Feb. 28, 2008),

<https://www.youtube.com/watch?v=PS5a6bVMHxw> (Ex.1169 and Ex.1170) at

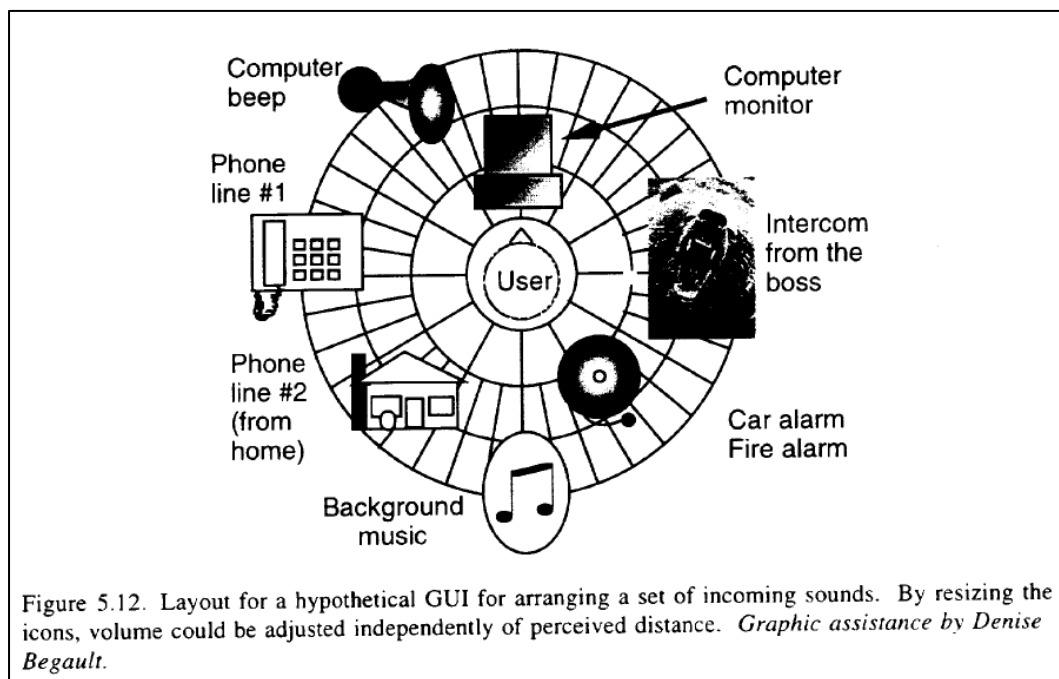
0:15-0:51 (at 4:50-5:26 in original video) (showing the user scrolling from the shotgun, to the green herbs, and to the spinel gem that is then selected for sale, and playing the associated sound effects to indicate highlighting and selecting). These sound effects, also referred to as “interface sound objects,” include “the sounds one hears when changing the different game settings, such as the controller functions” and “onscreen representation of objects carried by the user.” Stockburger (Ex.1157) at Section 4.5. Thus, it would have been obvious for persons of ordinary skill in the art to implement them in a Pedrotti-Jang or Pedrotti-Jang-Begault system.

78. Begault further renders obvious the binaural sound playback recited in limitation 1[c] and claim 10 through its disclosures of 3D sound system interfaces and the use of binaural sounds for interface navigation. Again, Patent Owner’s assertion that “Begault simply provides a user interface that enables configuration of sound sources for subsequent received sound” (POR at 11) is wrong.

79. For example, Begault discloses a system with a touch panel that used spatialized sounds for menu selections. Begault (Ex.1007) at 159, Fig. 5.1. As another example, Begault discloses a “3-D audio subsystem [that] is specified to match the position of a mouse click anywhere on a computer monitor screen, relative to an arbitrary audio mapping position.” Begault (Ex.1007) at 160, Fig. 5.2.

80. Skilled artisans would have known and been motivated to apply such teachings to Begault’s Figure 5.12 GUI, *e.g.*, to have each of the icons in the GUI

play a related sound as the user moves a controller to point to different icons (which could be simultaneously highlighted in response to the pointing in order to convey potential selection). As I have explained, this type of sensory feedback, including to facilitate selection, was known to be essential. Thus, as a user could move his/her controller, first pointing at the “Computer monitor” on the interface, then the “Computer beep,” then the “Intercom from the boss” in Begault’s Figure 5.12 GUI, and those SLPs could obviously play the binaural sounds associated with them (and show appropriate highlighting).



Begault (Ex.1007) at Fig. 5.12.

81. Alternatively, as the user navigates the GUI, sounds as simple as the spatialized clicks that Begault discloses could be used, to let the user know he/she is

traversing the interfaces. Begault teaches this, as noted, and multiple additional examples from the prior art, *e.g.*, from the Second Life videos discussed above, show how commonplace such sounds were. Specifically, persons of ordinary skill in the art would also see the resemblance between the GUI in Begault’s Figure 5.12 and the pie menus of Second Life that I discuss above, which demonstrates the synchronized visual highlighting and accompanying sounds—clicks and tonal sounds.

* * *

82. For the reasons set out above and in my opening declaration, it is my opinion that Pedrotti in view of Jang, and Pedrotti in view of Jang and Begault, teach and render obvious limitation 1[d] and claim 10.

3. Dependent Claim 2

83. I understand that Patent Owner contends that the Ground 1 prior art does not teach or render obvious limitation 2[a]’s “tracking, with one or more sensors in the WED worn on the head of the user, the PED to determine when the PED moves outside the zone.” Specifically, I understand that Patent Owner argues that Pedrotti’s disclosures are insufficient because, in Patent Owner’s view, this limitation “expressly requires that the WED’s sensors track the PED.” *See* POR at 15, 18. I disagree, for multiple reasons.

84. First, limitation 2[a] does not require “that the WED’s sensors track” anything (POR 15, 18); this limitation recites “tracking, *with* one or more sensors in the WED worn on the head of the user, the PED.” The sensors need not track. Rather, the *system* tracks using sensors. Indeed, sensors do not track. Sensors *sense* and other components of VR and AR systems track with information sensed by the sensors. And the ’509 patent itself shows that Patent Owner’s argument is misplaced.

85. For example, claim 17 recites a WED that includes “*sensors that sense.*” ’509 patent (Ex.1001-509) at cl. 17. And the ’509 patent’s specification is consistent with what a skilled artisan would know—a combination of hardware, including a processor in addition to sensors, is required to perform tracking like that claimed. The specification discloses that the WED includes “a processor or processing unit 1574,” and “a motion or location tracker 1582,” both of which are separate from “one or more sensors 1580.” ’509 patent (Ex.1001-509) at 34:20-29; Fig. 15:

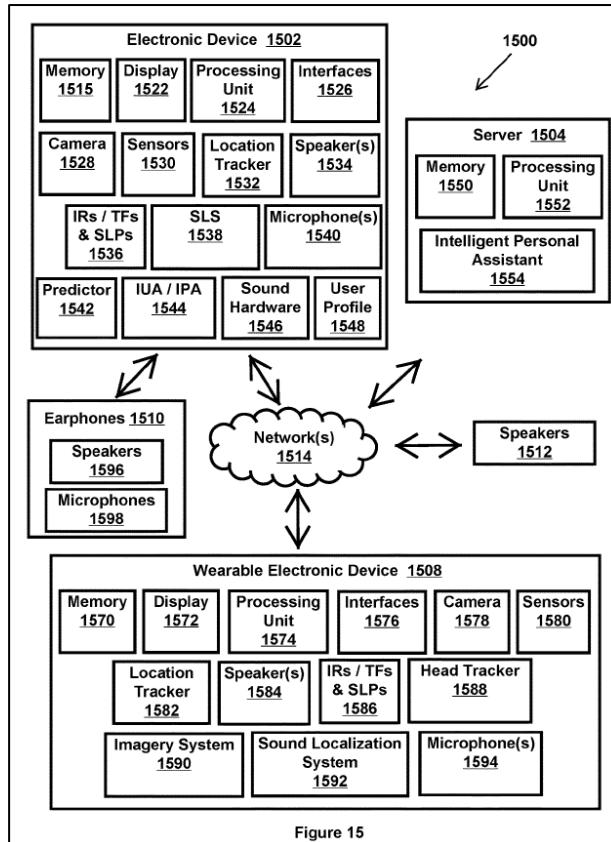


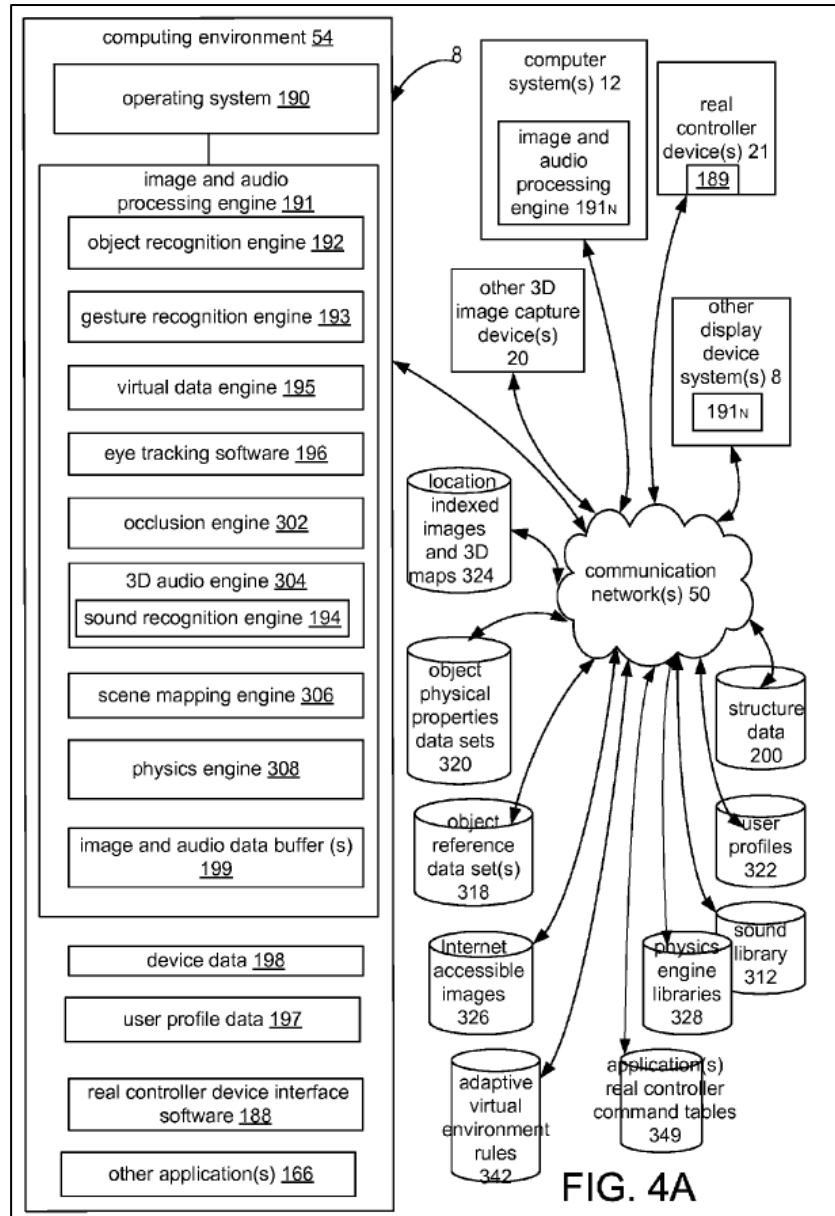
Figure 15

86. Put simply, Patent Owner’s assertion that the WED’s sensors alone must track is technologically inaccurate. The reality of systems like those disclosed in the ’509 patent and the prior art, *e.g.*, Pedrotti, is that sensors sense and collect information, and other components, such as processors, make determinations and track with that information. *See, e.g.*, Pedrotti (Ex.1005) at 4:59-61 (“Such trackers, ***and the processors which determine the position and orientation of such trackers,*** are well known to those of skill in the art.”) (emphasis added).

87. For example, in my 2002 “No Silver Bullet” article with Eric Foxlin, we state that “motion tracking systems most often derive pose estimates from

electrical measurements of mechanical, inertial, acoustic, magnetic, optical, and radio frequency sensors” (Welch, “No Silver Bullet” (Ex.1135) at 25–26) and discuss processing throughout. And, in 2001, at ACM SIGGRAPH 2001, Danette Allen, Gary Bishop, and I taught a course titled “Tracking: Beyond 15 Minutes of Thought.” In the course pack, we discuss typical systems and sensors used for tracking, including inertial tracking, magnetic tracking, mechanical tracking, and optical tracking. *See* Allen (Ex.1172) at 31–58 (“Classifications of Devices and Systems”). We also then discuss approaches to using the sensor information to determine and track the position and orientation of an object. *See* Allen (Ex.1172) at 59–70 (“Approaches”); *see also* Welch, “No Silver Bullet” (Ex.1135).

88. As another example, the detailed diagram of the computing environment 54 of McCulloch’s system includes an “image and audio processing engine 191” that is separate from “device data 198,” which “may also include data from sensors or sensing units or determined from the sensors or sensing units.” McCulloch (Ex.1008) at 24:9-21, 14:23-32 (explaining that “[i]mage and audio processing engine 191 processes ... information [that] may come from the outward facing capture devices 113 ... and additionally based on captured data from other display device systems 8.”).



McCulloch (Ex.1008) at Fig. 4A.

89. Second, I understand that, in addition to its flawed argument based on limitation 2[a] requiring sensors that track, Patent Owner criticizes my discussion of three of the multiple references I discussed in my opening declaration that confirm the obviousness of limitation 2[a]—namely, Ambrus (Ex.1043), McCulloch

(Ex.1008), and Jerald, THE VR BOOK (Ex.1063)—contending that these three references do not disclose or teach tracking anything other than the HMD itself. Patent Owner’s contentions about these references are incorrect.

90. Patent Owner argues that the sensors in Ambrus’s HMD do nothing more than “track [] the HMD itself,” and that the sensors in Ambrus’s HMD do not track controllers held in the hand of a user. POR at 26. Not so.

91. Ambrus teaches that an HMD can include many types of sensors, that can be utilized as part of the tracking of gestures, movements, and other objects and entities other than the HMD itself: “In some examples the HMD device 700 may also include an optical sensor system that utilizes one or more outward facing sensors, such as color camera 712 or depth camera 714 on HMD device 700, to capture image data. *The outward facing sensor(s) may detect movements within its field of view, such as gesture-based inputs or other movements performed by a user or by a person or physical object within the field of view.* The outward facing sensor(s) may also capture 2D image information and depth information from the physical environment and physical objects within the environment.” Ambrus (Ex.1043) at ¶ 76 (emphasis added); Welch (Ex.1003) at ¶ 91.

92. Ambrus further discloses other tracking systems including a structured light depth camera that can “project a pulsed infrared illumination onto a scene,” which can also be used for tracking a hand, controller, or other objects in a scene.

Ambrus (Ex.1043) at ¶ 78. Ambrus’s disclosure of “outward facing sensor(s)” teaches that the sensors in Ambrus’s HMD are not utilized solely for the purpose of tracking the HMD. In fact, Ambrus expressly discloses tracking gesture-based inputs, which also suggests tracking controllers held in user’s hands. Further, Ambrus also discloses using images from the outward facing depth sensors for modeling the real world around the user, for mixed reality applications: “The outward facing sensor(s) may capture images of the physical environment in which a user is situated. With respect to the HMD device 700, in one example a mixed reality display program may include a 3D modeling system that uses such captured images to generate a virtual environment that models the physical environment surrounding the user.” Ambrus (Ex.1043) at ¶ 79.

93. As with Ambrus, Patent Owner argues that McCulloch’s disclosures are limited to tracking the location of the HMD and the user, not controllers. POR at 26-27. This is also wrong.

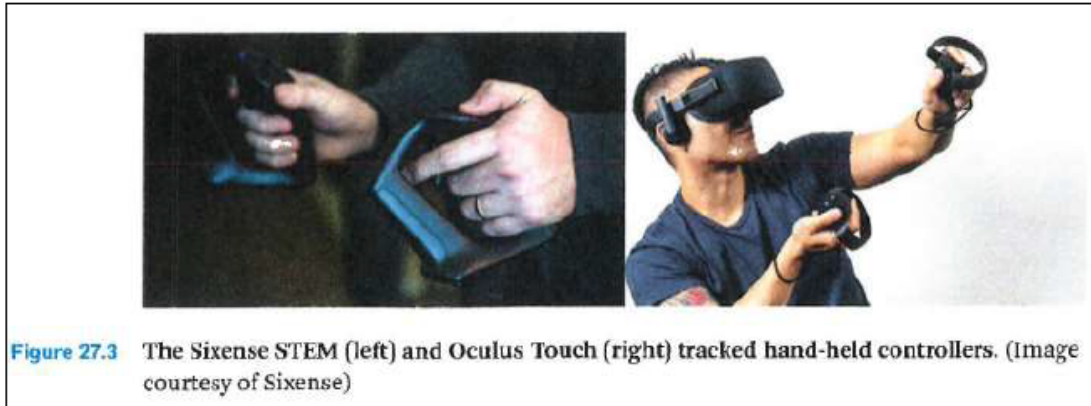
94. McCulloch discloses “one or more 3D image capture devices, 20 which may be, for example, one or more cameras that visually monitor one or more users and the surrounding space such that gestures and movements performed by the one or more users, as well as the structure of the surrounding space including surfaces and objects, may be captured, analyzed, and tracked.” McCulloch (Ex.1008) at 6:21-29, 14:53-59 (disclosing a “gesture recognition engine 193” to support such

tracking). McCulloch further discloses that such information may be used “for identifying gestures to indicate one or more controls or actions,” and therefore teaches that such image capture devices are capable of similarly tracking controllers held in the hand of a user. McCulloch (Ex.1008) at 6:29-33; *see also* McCulloch (Ex.1008) at 6:40-54 (describing use of RGB, IR, time-of-flight, structure light, and stereo image for image capture). Still further, McCulloch discloses that such information can be used for various other purposes related to scene modeling and understanding. *See, e.g.*, McCulloch (Ex.1008) at 17:22–27 (“A 3D point cloud representing the surfaces of objects including things like walls and floors in a space can be generated based on captured image data and depth data of the user environment. A 3D mesh of the surfaces in the environment can then be generated from the point cloud.”), 17:47–48 (“A polygon mesh may also be used to represent the object’s boundary as mentioned above.”), 20:64–21:1 (“The occlusion engine 302 identifies spatial occlusions between objects, and in particular between real and virtual objects based on spatial position data for recognized objects within a coordinate system as updated by the objection recognition engine 192 and the scene mapping engine 306.”).

95. Additionally, McCulloch discloses that “capture devices 113 are also referred to as outward facing capture devices meaning facing outward from the user’s head.” McCulloch (Ex.1008) at 7:57-59. As noted above, the disclosure of

“outward facing capture devices” teaches and suggests to any skilled artisan sensors in an HMD that are used for more than just tracking the HMD, including—obviously—controllers.

96. Regarding Jerald, THE VR BOOK, Patent Owner argues that Jerald, THE VR BOOK does not “state that hand-held tracked devices are tracked by sensors in the HMD worn by the user.” POR at 27-28. But Jerald, THE VR BOOK correctly notes that handheld controllers were frequently tracked with “inertial, electromagnetic, ultrasonic, or optical (camera) technologies,” in a non-limiting way. Such methods of tracking could be supported by sensors in the HMD that gather the respective data. For instance, it would hardly make sense for camera technologies and image capture devices to track handheld controllers through placement of the cameras on the controllers themselves. A person of ordinary skill in the art would have understood that the described means of tracking could be implemented by placing sensors and trackers in and on HMDs. As the Jerald, THE VR BOOK explains a “camera-based system might be used *with* tracked hand-held controllers.” Jerald, THE VR BOOK (Ex.1063) at 311, 314 (“Tracked hand-held controllers” “have been used for decades”), Fig. 27:3 (showing hand-held controllers that skilled artisans knew were tracked with sensors in HMDs):



97. As I explained in my opening declaration, many systems with HMDs had sensors, *e.g.*, cameras, for sensing and thus gathering information external to the HMD, including for tracking controllers. *See* Op. Decl. §VII.D. Such systems were well-known and persons of ordinary skill in the art would have known and been motivated to use them in a Pedrotti-Jang system and a Pedrotti-Jang-Begault system, consistent with Pedrotti’s disclosures.

98. Third, I understand that Patent Owner criticizes my testimony about HMDs that use sensors to track controllers. *See* POR at 24-25. I have reviewed Patent’s Owner’s arguments about my testimony, and I disagree with them.

99. I did not testify that “there are only two ways for tracking a user’s head using sensors and trackers” (POR at 24). Nor would I. As I and others have written about extensively over the past decades, *e.g.*, Welch, *No Silver Bullet* (Ex.1135) and Allen (Ex.1172), there are many well-known ways of tracking a user’s head using a wide range of physical mediums and associated sensors and sources. And, during

my deposition, I made clear that the figure I discussed in paragraph 87 of my opening declaration, with Patent Owner emphasizes, is just an illustration; it does not relate to any actual system and is not, by any means, definitive. *See* Welch Dep. Tr. (Ex.2012) at 212:21-222:20, 232:20-233:15 (explaining that this figure was just “meant to illustrate this particular notion of what sometimes people would call outside looking in and sometimes would call inside looking out[,] as imperfect as those terms may be”).

100. Similarly, I did not testify that “track[ing] a tracker attached to a part of the user’s body by sensors mounted on the user’s head” would be “pretty hopeless,” or that “no sane person... would ever attempt to do that” (POR at 25). I reproduce my actual testimony below, because it demonstrates the erroneous way Patent Owner quotes limited phrases of my testimony out of context. As my actual testimony shows, at my deposition, in the portions of testimony Patent Owner cites, I was trying to explain to Patent Owner why the convoluted hypotheticals it posed were nonsensical:

[I]f you mean all of the landmarks we are using, every single landmark you were trying to use, and every single landmark was moving independently of other landmarks and you have no idea why they were moving or how they were moving, it’s hard for me to imagine how just using the optical sensors you would be able to do that. If you wanted

to do that, a person of ordinary skill would – it’s probably pretty hopeless.

Welch Dep. Tr. (Ex.2012) at 227:5-228:13.

If you want to ask me if you put a camera on your head and it’s looking down at your chest and it only sees your chest, can you track where you are in the world or in the room, probably not. I mean, if that’s all you have, but no sane person of ordinary skill or sane person in general who knows something about sensors and system[s] like this would ever attempt to do that. It just doesn’t make sense.

Welch Dep. Tr. (Ex.2012) at 233:17-235:10; *see also* Welch Errata Sheet (Ex.1171).

* * *

101. For the reasons set out above and in my opening declaration, it is my opinion that Pedrotti in view of Jang, and Pedrotti in view of Jang and Begault, teach and render obvious limitation 2[a].

4. Independent Claim 17

102. I understand that Patent Owner asserts that the Ground 1 prior art does not teach or render obvious limitation 17[e], which requires a WED that “includes one or more sensors that sense when the PED leaves the zone.” POR at 12-13. Patent Owner’s arguments on this point do not raise any new issues beyond those I discussed above or addressed in my opening declaration. *See* §V.B.3; *see also* Op. Decl. ¶¶ 294-296. As I previously explained, the slight differences in language

between limitation 17[e] and 2[a] do not alter the fact that, to persons of ordinary skill in the art, limitation 17[e] would have been obvious over Pedrotti and Jang, and over Pedrotti, Jang, and Begault. Op. Decl. ¶¶ 292-302, 392.

5. Other Claims

103. Patent Owner does not advance any arguments relating to dependent claims 3-8, 12-14, and 18-20 other than those I addressed above in the context of the independent claims. Thus, for reasons I have explained above and in my opening declaration, it is my opinion that claims 3-8, 12-14, and 18-20 would have been obvious over the Ground 1 prior art. Op. Decl. ¶¶ 310-360, 382-384, 396-404.

VI. Ground 2

A. Skilled Artisans Would Have Known and Been Motivated to Combine McCulloch and Pedrotti, and McCulloch, Pedrotti, and Flaks

104. In my opening declaration, I explained why persons of ordinary skill in the art would have known and been motivated to combine the teachings of McCulloch and Pedrotti (Op. Decl. §X.B.1), and why persons of ordinary skill in the art would have known and been motivated to combine the teachings of McCulloch, Pedrotti, and Flaks (Op. Decl. §X.B.2). Those opinions, as noted, are fully incorporated here.

105. In the Patent Owner's Response, Patent Owner does not contest my opinions relating to the reasons skilled artisans would have combined the Ground 2 prior art references, including my opinions that the prior art references relied on in

Ground 2 are analogous prior art. Nevertheless, for reasons discussed below, I provide additional information here relating to why Petitioners' Ground 2 prior art—McCulloch, Pedrotti, and Flaks—is analogous art to the '509 patent.

106. As I explained above in discussing Ground 1, Pedrotti is analogous art to the '509 patent. *See* §V.A.

107. McCulloch, like Pedrotti, is analogous art to the '509 patent because it is from the same field of endeavor, and it is reasonably pertinent to the problems with which the inventor(s) were allegedly involved (*e.g.*, interacting with and controlling virtual objects in virtual environments). McCulloch describes a system involving an HMD, *i.e.*, a WED worn on a user's head, and discloses, among other things, ways to control virtual objects and sound presented to users with the HMD. *See, e.g.*, McCulloch (Ex.1008) at 1:18-21 (disclosing system for “controlling a virtual object displayed by a near-eye, augmented reality display with a real controller device”), 20:11-13 (“For example, a gaming application may receive user input identifying boundaries for a playspace in which virtual objects can be positioned.”), 25:60-26:19 (describing a 3D audio engine that “plays audio data for the virtual object projected from a 3D space position of the virtual object”), 26:7-19 (describing that each virtual object is associated with “audio data... projected from a 3D space position of the virtual object” generated through HRTFs processed by the 3D audio engine); *see also* McCulloch (Ex.1008) at 7:24-67 (describing capture

devices), 8:17-39 (describing sensors incorporated into McCulloch's HMD), 15:31-38 (explaining that sensor data, *e.g.*, head position data, is used to map what is in and around the user's environment); Op. Decl. §IX.D (Overview of McCulloch).

108. Flaks, like Pedrotti and McCulloch, is analogous art to the '509 patent because it is from the same field of endeavor, and it is reasonably pertinent to the problems with which the inventor(s) were allegedly involved (*e.g.*, controlling binaural sounds in virtual environments). Flaks describes, among other things, various techniques to render spatialized sound in virtual environments, including for the purposes of augmented reality (AR). *See* Flaks (Ex.1009) at 1:40-43 ("One possible use of 3D audio is in augmented reality scenarios. Augmented reality may be defined as using some computer generated technique to augment a real world situation."), Abstract (disclosing techniques "for providing 3D audio," where "the 3D audio signal may include a number of components that are determined based on collected sensor data and the listener's location audio data for the virtual object projected from a 3D space position of the virtual object"), 3:21-24 (disclosing "[a] 3D audio signal may be generated based on sensor data collected from the actual room in which the listener is located and the actual position of the listener in the room"), 11:44-12:57 (disclosing a process of "determining an HRTF for a particular listener," which can be stored for the user and updated "in real time" based on "changing user position"); *see also* Op. Decl. §IX.D (Overview of McCulloch).

B. Claims 1-14 and 17-20 Would Have Been Obvious Over McCulloch and Pedrotti, And Over McCulloch, Pedrotti, and Flaks

109. In this section, I address Patent Owner's arguments about the Ground 2 prior art and the obviousness of challenged claims 1-14 and 17-20. Again, I begin with claim 9.

1. Independent Claim 9

110. I understand that Patent Owner contends that neither the combination of McCulloch and Pedrotti nor the combination of McCulloch, Pedrotti, and Flaks, teaches or suggests limitation 9[b], which recites "determining, with a wearable electronic device (WED) worn on a head of the user, when the user is located inside the zone." POR at 46. I disagree.

111. I understand that, in addressing Ground 2, Patent Owner refers back to the arguments about Pedrotti it raised in the context of Ground 1. POR at 46. For the same reasons I discussed above, those arguments are misplaced and incorrect. Pedrotti renders limitation 9[b] obvious. *See* §V.B.1.

112. Additionally, with respect to McCulloch, which likewise renders limitation 9[b] obvious, Patent Owner fails to explain why it contends McCulloch's disclosures are insufficient. *See* POR at 46. In the Patent Owner's Response, Patent Owner's entire argument relating to McCulloch and limitation 9[b] consists of two sentences. In the first, Patent Owner admits that McCulloch discloses HMDs with

sensors in them. POR at 46 (“Petitioner references portions of McCulloch that disclose[] sensors in and HMD.”). Yet in the second, Patent Owner writes, “But these cite[d] portions do not teach that the act of determination is performed by a processor in the HMD.” POR at 46. I disagree with Patent Owner’s one-sentence argument, which lacks explanation or citations of any kind. This argument does not, in any way, alter my opinion that, to persons of ordinary skill in the art, limitation 9[b] would have been obvious over McCulloch, including in view of McCulloch’s disclosure that its HMD includes absolute position and orientation tracking of the HMD through the use of multiple types of sensors and transceivers. *See Op. Decl.* ¶¶ 451-454, 476, 530.

113. For at least these reasons, as well as those set out in my opening declaration, it is my opinion that the Ground 2 art teaches, or at a minimum renders obvious, limitation 9[b], and Patent Owner’s arguments about this limitation are misplaced and incorrect.

2. Independent Claim 1 and Dependent Claims 10 and 11

114. I understand that Patent Owner contends that neither the combination of McCulloch and Pedrotti nor the combination of McCulloch, Pedrotti, and Flaks teaches or suggests limitation 1[c], limitation 1[d], claim 10, or claim 11. POR at 33-34, 47. I also understand that, in the context of Ground 2, Patent Owner again focuses on claim language requiring (1) highlighting an SLP when a handheld PED

is pointed at the SLP while a user is located in the zone (limitation 1[c] and claim 11) and (2) playing binaural sound in response to pointing (limitation 1[d] and limitation 10[b]), and now also presents arguments concerning (3) determining, with the WED, when the PED is pointed at one of the SLPs while the user is located in the zone (limitation 10[a]). I disagree with each of Patent's Owner's incorrect arguments about these issues.

115. As an initial matter, I disagree with Patent Owner's argument that the Ground 2 art does not teach or suggest the claimed highlighting of limitation 1[c] and claim 11 and the claimed binaural sound playback of limitation 1[d] and claim 10 because, for reasons I discussed above in the context of Ground 1 as well as in my opening declaration, Pedrotti renders obvious the claimed highlighting when a PED is pointed at an SLP and the claimed sound playback in response to such pointing, which, in view of McCulloch and Flaks, obviously would be binaural. *See* §V.B.2; *see also* Op. Decl. ¶¶ 83, 262-289, 418-419, 442-445, 458-471.

116. Additionally, the claimed highlighting of limitation 1[b] and claim 11 and the claimed binaural sound playback of limitation 1[c] and claim 10 would have been obvious to persons of ordinary skill in the art over McCulloch and Pedrotti, and over McCulloch, Pedrotti, and Flaks.

117. McCulloch describes using real controller devices, PEDs, to point at, select, and control virtual objects, such as a virtual basketball or a virtual helicopter.

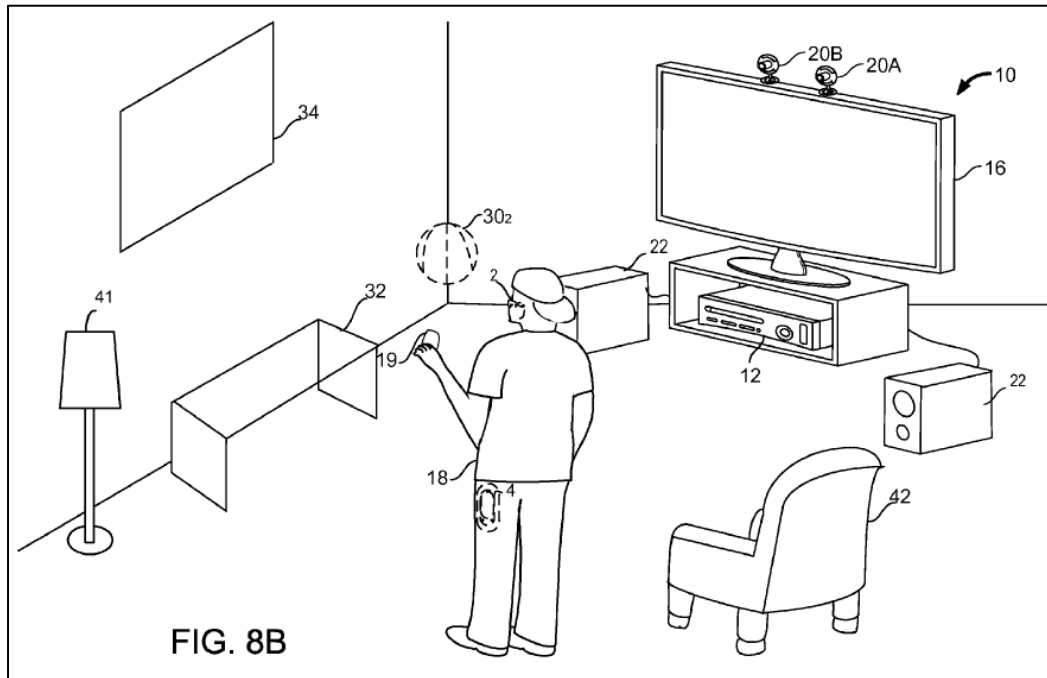
McCulloch (Ex.1008) at 28:51-29:63, Figs. 8B, 8D, 26:7-19; *see also* McCulloch (Ex.1008) at 29:4-12 (disclosing “an example of a virtual object representation of the user selected real object being controlled with McCulloch’s controller. The changes in position and orientation of McCulloch’s controller causes its inertial motion unit to generate one or more signals which are converted by the handheld IMU real controller device 19 to be user input requesting display of an action by the virtual object 30₂ representing the real basketball based on the user perspective”). And as I explained in discussing Ground 1 (*see* Section V.B.2.a), as well as in my opening declaration, skilled artisans would have known and been motivated to highlight and play sounds from McCulloch’s virtual objects, including the basketball, the helicopter, and a virtual television, when a user points McCulloch’s handheld controller at them, for example, to facilitate the user’s interaction with such objects. Op. Decl. ¶¶ 442-445, 464-469, 471. In fact, McCulloch expressly teaches skilled artisans that its system can use such highlighting, as it discloses a “visual effects library” with “routines for... highlighting” for use with “actions, pre-collision events and collision events,” McCulloch (Ex.1008) at 23:4-7, and McCulloch (with or without Flaks, which McCulloch incorporates by reference) teaches a “positional 3D audio engine” that associates “[a]udio data from a sound library” with “one or more collisions or actions” in a virtual environment, “so that the 3D audio engine [] will play the audio data during display of one or more collisions or actions,” McCulloch

(Ex.1008) at 21:21-38; *see also* McCulloch (Ex.1008) at 22:66-23:4 (“The sound library 312, besides being a resource for command and object recognition based on sound, may also store audio data for sound effects to be played by the 3D audio engine 304 and which may be linked with different simulated actions, pre-collision events and collision effects.”).

118. Also, persons of ordinary skill in the art would have understood that McCulloch’s virtual objects (such as the virtual basketball depicted in Figures 8B and 8D, and others such as the helicopter and television disclosed in McCulloch) are, or obviously are, SLPs—they are positioned at locations in the virtual environment, and they emit binaural sound. *See, e.g.*, McCulloch (Ex.1008) at 26:7-19 (flying helicopter crashes into wall), 29:3-30:3 (bouncing basketball that crashes into television), 25:6-26:34, Fig. 5 (describing “play[ing] audio for the virtual object projected from a 3D space position of the virtual object”), Figs. 8A-8D, 24:67-25:3; *see also* Op. Decl. ¶¶ 443-445 (further discussing McCulloch’s and Flaks’ disclosures relating to producing binaural sounds at the locations of virtual objects, i.e., SLPs).

119. Notwithstanding the above, Patent Owner argues that McCulloch does not disclose “pointing a PED at an SLP or highlighting a SLP as claimed.” POR at 33. I disagree.

120. McCulloch's Figure 8B depicts a user pointing a handheld controller (19) at a virtual basketball (30₂):

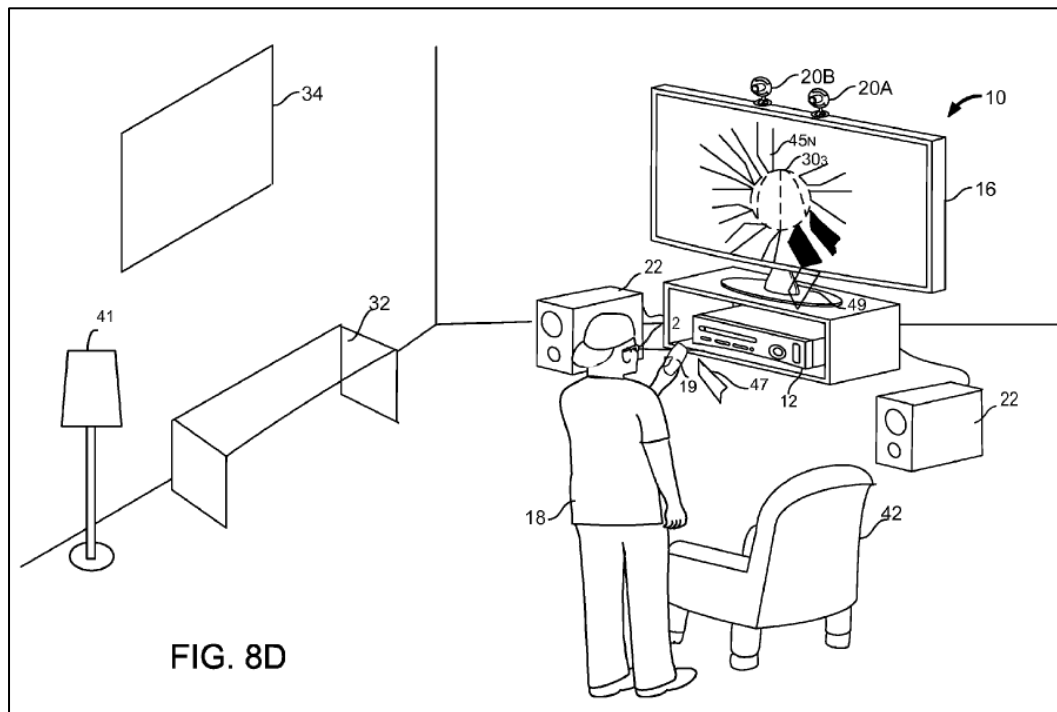


McCulloch (Ex.1008) at Fig. 8B, 29:4-16 (describing same). Persons of ordinary skill in the art would have known and been motivated to highlight the virtual basketball depicted above when the user points the controller at it, *e.g.*, to facilitate its selection or movement. Again, McCulloch discloses the use of “highlighting” for “actions” and “pre-collision events” in its virtual environment. McCulloch (Ex.1008) at 23:4-7. In fact, it would be particularly obvious to persons of ordinary skill in the art to highlight the virtual basketball—*e.g.*, through a change of color, an increase in brightness, the addition of a distinct outline, or other change in display—when, as McCulloch teaches, the “real basketball 30” that “virtual basketball 30₂” is

designed to represent is “erased.” McCulloch (Ex.1008) at 29:11-16. Persons of ordinary skill in the art also would have known and been motivated to play binaural sound in response to the user pointing his controller at the virtual basketball—for example, with something thematic, such as the sound of a dribble, a swishing net, a sneaker on a court, an air horn, the NBA theme song, etc., or something as simple as a click—*e.g.*, to facilitate the basketball’s selection or movement, as well as to make the user’s interactions with the basketball more affirmative and engaging. *See* McCulloch (Ex.1008) at 21:21-38 (McCulloch’s 3D audio engine associates “[a]udio data from a sound library” with “actions” in the virtual environment and “will play the audio data during display of” such “actions”), 22:66-23:4. And, persons of ordinary skill in the art would have known that the sound-producing virtual basketball’s location (at which the user points) is, or is obviously, an SLP. Moreover, persons of ordinary skill in the art reading the Ground 2 art would have known and been motivated to use the claimed highlighting and binaural sound playback for user interactions with other virtual objects beyond the virtual basketball depicted in McCulloch’s Figure 8B, such as McCulloch’s virtual helicopter, which obviously would make rotor whirring sounds, or other virtual objects, *e.g.*, Pedrotti’s virtual weapons, toys, and other devices and objects, or the virtual monsters disclosed in Mount 350, incorporated by reference in McCulloch (*see* Pedrotti

(Ex.1005) at 5:47-53, 16:33-42; Mount 350 (Ex.1027) (incorporated by reference in McCulloch (Ex.1008) at 20:60-63), [0042].

121. McCulloch's Figure 8D depicts a user pointing a controller (19) at a virtual basketball (30₃) and a television (16), which virtually cracks (45_N) and breaks into pieces (47, 49) as a result:



McCulloch (Ex.1008) at Fig. 8D, 29:36-63 (describing same). Persons of ordinary skill in the art reading the Ground 2 art would have known and been motivated to use the claimed highlighting and binaural sound playback when the user points the handheld controller controlling the virtual basketball at the television, causing the

collision depicted.⁴ As noted, McCulloch discloses the use of “highlighting” for “collision events” (McCulloch (Ex.1008) at 23:4-7), and skilled artisans would have known that highlighting the virtual collision caused by the user pointing the controller at the television—*e.g.*, increasing the brightness of the colliding objects or otherwise changing their colors or display—would make the collision more engaging and entertaining for the user. Similarly, persons of ordinary skill in the art

⁴ McCulloch explains that the user, “Joe,” “has moved the handheld IMU device with such an intensity in the direction of the television 16 that the virtual basketball 303 collides with the display of the television.” McCulloch (Ex.1008) at 29:36-46. Persons of ordinary skill in the art would have understood that, as Figure 8D shows, Joe has moved his handheld controller from pointing at a starting location for the virtual basketball (as shown in Figure 8B) to pointing at (or at a minimum obviously pointing at) the location of the virtual basketball’s collision with the television (as shown in Figure 8D). And as I discuss further above line, Joe’s pointing his controller at the location of the collision, which is an SLP, results in, or at a minimum obviously results in, the highlighting of virtual objects at, and the playback of binaural sound from, that location.

would have known and been motivated to play binaural sound in response to the pointing that causes the collision depicted in Figure 8D—for example, a crashing sound, or the sounds for the virtual television’s glass cracking, breaking, and falling to the floor—for the same reasons, as well as to make the virtual environment more immersive. As I discussed previously, McCulloch teaches that its 3D audio engine associates “[a]udio data from a sound library” with “collisions” and “will play the audio data during display of one or more collisions.” McCulloch (Ex.1008) at 21:21-38, 22:66-23:4. And McCulloch discloses that the virtual television depicted in Figure 8D “not only cracks, as illustrated by cracks like path representative crack 45N, but breaks resulting in glass pieces 49 and 47 separating from the display and falling to the ground.” McCulloch (Ex.1008) at 29:46-55. Persons of ordinary skill in the art also would have known that the location of the virtual basketball’s collision with the television (at which the user points, as shown) is, or is obviously, an SLP. If the television is designed to be virtually breakable, it needs to be able to make a virtual breaking sound. *See, e.g.*, McCulloch (Ex.1008) at 21:34–38 (“Audio data from a sound library 312 may be associated with one or more collisions or actions for a particular physics model by an application or a user so that the 3D audio engine 304 will play the audio data during display of one or more collisions or actions.”). Moreover, as I noted above, persons of ordinary skill in the art reading the Ground 2 art would have known and been motivated to use the claimed highlighting and

binaural sound playback for interactions and collisions with other virtual objects beyond the virtual basketball depicted in McCulloch's Figure 8D, such as McCulloch's virtual helicopter, Pedrotti's virtual weapons, toys, and other devices and objects, or Mount 350's virtual monsters (*see* Pedrotti (Ex.1005) at 5:47-53, 16:33-42; Mount 350 (Ex.1027) (incorporated by reference in McCulloch (Ex.1008) at 20:60-63), [0042]). McCulloch discloses the simultaneous participation of multiple users who would each be at different locations and potentially looking in different directions. *See, e.g.*, McCulloch (Ex.1008) at 6:12–15 (“The user and his friends may be wearing their display device systems for playing a game which takes place throughout the house. As each player moves about the house, his environment changes.”), 6:24–25 (“one or more cameras that visually monitor one or more users”), 15:53–54 (“as one or more users enter or re-enter the environment”), 17:5–7 (“3D map updates can then be sent to the multiple display device systems 8 in the environment.”). Skilled artisans would have understood that the spatialization of a sound relative to each individual user is crucial to reinforce a common sense of the absolute locations of the virtual objects in the shared environment.

122. For at least these reasons, as well as those set out in my opening declaration, the Ground 2 art teaches, or at a minimum renders obvious, the highlighting and binaural sound playback recited in limitation 1[c], limitation 1[d],

claim 10, and claim 11, and Patent Owner's arguments about those limitations and claims are misplaced and incorrect.

123. I understand that Patent Owner also contends that the Ground 2 prior art does not teach or suggest limitation 10[a], which recites, "determining, with the WED, when the PED is pointed at one of the SLPs while the user is located in the zone." POR at 47. I disagree. *See* Op. Decl. ¶¶ 535-537, §§X.B.3.d, X.B.4.c(1).

124. Patent Owner argues that "even if McCulloch's controllers communicate information about their location to the HMD, that does not necessarily mean that the HMD can determine 'when the PED is pointed at one of the SLPs while the user is located in the zone' as claimed." POR at 47. Patent Owner, however, ignores multiple disclosures in McCulloch that render limitation 10[a] obvious, which I addressed in my opening declaration, including in my discussions of similar limitations (*e.g.*, limitations 1[c] and 4[a]), which were cross-referenced in my discussion of limitation 10[a]. *See* Op. Decl. ¶¶ 535-537 (limitation 10[a]), §§X.B.3.d (limitation 1[c]), X.B.4.c(1) (limitation 4[a]).

125. As I explained in my opening declaration, McCulloch's computing environment 54 receives device data 198, which includes data from the HMD itself, *e.g.*, "data from sensors or sensing units" such as "the orientation sensors in inertial sensing unit 132" and "location and proximity transceivers in location sensing unit 144." McCulloch (Ex.1008) at 24:14-21; *see also* McCulloch (Ex.1008) at Fig. 4A

(McCulloch's computing environment 54 is a component of McCulloch's display device system 8, i.e., the HMD). And McCulloch discloses, or at a minimum renders obvious, tracking the movement of its controllers such that its system determines with the HMD where the handheld controller is pointed. *See* McCulloch (Ex.1008) at 24:28-35 (discussing communication between the real controller device interface software and the device display system that resides within McCulloch's HMD), 29:4-63 ("Inertial motion sensors (not shown) in the handheld real controller device 19 identify parameters like speed, acceleration and direction of motion of the device which is sent as data to the display device system 8."); *see also* McCulloch (Ex.1008) at Fig. 2A, 8:1-16 (depicting and describing the circuitry, processors, and sensing units in McCulloch's HMD), Figs. 8B and 8D (which, as discussed above, show that McCulloch's system makes, or at a minimum obviously makes, determinations with the HMD about where the user's controller is pointing, including determining when the controller is pointed at an SLP, *e.g.*, the location of a sound-producing collision).

126. I note that the Patent Owner's Response contains no substantive arguments relating to (let alone rebutting the import of) the McCulloch disclosures I discuss above and discussed in my opening declaration.

127. I further note that Patent Owner's unsubstantiated argument that McCulloch does not teach or suggest that its HMD can determine when a PED is pointed at an SLP is belied by Patent Owner's pre-institution expert, Dr. Hart, who

(i) recognized that “McCulloch describes an example in which the controller device controls virtual object representation based on changes in relative positional and orientation changes of the handheld controller to cause its inertial motion unit to generate signal commands,” Hart Declaration (Ex.2001) at ¶ 67 (citing McCulloch, 29:4-17), and (ii) further opined that it follows that the “tracking performed by the HMD of the controller device in McCulloch is for the purpose of controlling a virtual object in a field of view based on inertial movements of the controller,” Hart Declaration (Ex.2001) at ¶ 67. In other words, it was obvious to Dr. Hart, who Patent Owner argued was a skilled artisan, that McCulloch’s HMD tracks controllers based on “positional and orientation changes” of the controller—i.e., that McCulloch’s system can “determin[e], with the WED, when the PED is pointed at” different virtual objects, as claimed. And, for reasons discussed, with the Ground 2 combinations, this would obviously include pointing at an “SLP,” and occur “while the user is located in the zone,” i.e., Pedrotti’s “safe area” zone.

128. Even if McCulloch did not disclose determination of when a PED is pointed at an SLP (which it does disclose), skilled artisans would have understood that for McCulloch’s system to function as described it would need to be able to continuously determine where each PED and each WED is positioned and oriented in the same coordinate frame—a common coordinate frame that is registered to the

real world. Without that, users would not see, hear, or be able to control the virtual objects from their own perspective, in a way that matches the other users.

129. For at least these reasons, as well as those set out in my opening declaration, it is my opinion that the Ground 2 art teaches, or at a minimum renders obvious, limitation 10[a], and Patent Owner’s arguments about this limitation are misplaced and incorrect.

3. Dependent Claim 2

130. I understand that Patent Owner contends that neither the combination of McCulloch and Pedrotti nor the combination of McCulloch, Pedrotti, and Flaks, teaches or suggests limitation 2[a], which recites “tracking, with one or more sensors in the WED worn on the head of the user, the PED to determine when the PED moves outside the zone.” *See* POR at 36-37. I disagree.

131. As an initial matter, limitation 2[a] would have been obvious based on Pedrotti’s teachings, for reasons I discussed above in Section V.B.3 and in my opening declaration. Op. Decl. ¶¶ 474-477.

132. Additionally, Patent Owner’s arguments about McCulloch’s disclosures are incorrect.

133. Patent Owner contends that two passages from McCulloch—specifically, McCulloch at column 4, lines 25 through 31, and McCulloch at column 13, line 52 through column 18, line 7—do not disclose controllers that are “tracked

with sensors in the HMD.” POR at 36-37. However, these passages, when considered in view of McCulloch as a whole, including multiple disclosures from McCulloch that I and Petitioners previously cited in discussing limitation 2[a] (*see* Op. Decl. ¶¶ 190-192, 194-196, 474-477), and the knowledge of persons of ordinary skill in the art, teach and suggest the claimed “tracking, with one or more sensors in the WED worn on the head of the user, the PED,” as claimed.

134. The passages from McCulloch on which Patent Owner focuses (4:25-31 and 13:52-18:7) teach that McCulloch’s system can use different types of controllers, including “a pointing device,” and comprises, among other things, an object recognition engine 192 and a gesture recognition engine 192 (13:52-14:11), memory for “receiving image data captured from the outward facing capture devices 113,” *e.g.*, cameras on the HMD (14:13-22), and an object recognition engine that “detects, tracks and identifies real objects in the display field of view and the 3D environment” (17:32-36). And, additional disclosures from McCulloch that Patent Owner ignores further teach that its controller may be a “pointing device” (25:25-28); tracking movement of McCulloch’s controller including where it is pointed (28:63-66, 29:11-15, Figs. 8B, 8D); “capture devices” and other “sensing units” incorporated in or on McCulloch’s HMD that provide information such as depth data and data related to McCulloch’s controller (5:19-36, 7:34-67, 8:17-39, 12:18-21); and that this information from these input devices or units are conveyed to the

engines incorporated in the HMD for processing (13:56-60, 14:23-32, 22:4-8, 24:9-21, 28:5-11, Fig. 4A).

135. Based on these disclosures from McCulloch, persons of skill in the art would have understood that McCulloch's system "track[s], with one or more sensors in the WED worn on the head of the user, the PED," as claimed, or, at a minimum, suggests and thus renders obvious such tracking. And, as I have explained elsewhere, Pedrotti teaches, or at a minimum renders obvious, "determin[ing] when the PED moves outside the zone." *See* §V.B.3; Op. Decl. ¶¶ 297-301.

136. Patent Owner also argues that Figure 9 shows that McCulloch's HMD "does not include a sensor." POR at 44. However, this figure does not contradict any of the many other disclosures and teachings in McCulloch that render limitation 2[a] obvious. McCulloch states that Figure 9 is a high-level block diagram that merely depicts "[s]ome examples of hardware components" in a "basic configuration." McCulloch (Ex.1008) at 5:25-26, 30:4-26 (describing Figure 9). Skilled artisans would have understood that such block diagrams are intended to convey functionality, independent of hardware and software design choices. Further, McCulloch does not describe the functionality depicted in Figure 9 as limiting. To the contrary, McCulloch teaches that "device 900 may also have additional features/functionality" and also that "[d]evice 900 may also have input device(s)

914.” McCulloch (Ex.1008) at 30:20-21. Persons of ordinary skill in the art would have known that one common example of a such an input device would be a sensor.

137. For at least these reasons, as well as those set out in my opening declaration, it is my opinion that the Ground 2 art teaches, or at a minimum renders obvious, limitation 2[a], and Patent Owner’s arguments about this limitation are misplaced and incorrect.

4. Dependent Claim 17

138. I understand that Patent Owner contends that neither the combination of McCulloch and Pedrotti nor the combination of McCulloch, Pedrotti, and Flaks, teaches or suggests limitation 17[3], which requires a WED that “includes one or more sensors that sense when the PED leaves the zone.” POR at 12-13.

139. I further understand, however, that Patent Owner’s arguments relating to limitation 17[e] do not raise any issues beyond those raised by Patent Owner’s arguments concerning limitations 2[a] and 17[e] in Ground 1 and limitation 2[a] in Ground 2.

140. Accordingly, for at least the reasons I discussed above, in the context of limitations 2[a] and 17[e] in Ground 1 and limitation 2[a] in Ground 2, as well as those set out in my opening declaration, it is my opinion that the Ground 2 art teaches, or at a minimum renders obvious, limitation 17[e], and Patent Owner’s arguments about this limitation are misplaced and incorrect.

5. Other Claims

141. The Patent Owner's Response does not advance any arguments relating to dependent claims 3-8, 12-14, and 18-20 other than those I addressed above in the context of the independent claims. Thus, for reasons I have explained above and in my opening declaration, it is my opinion that claims 3-8, 12-14, and 18-20 would have been obvious over the Ground 2 prior art. Op. Decl. ¶¶ 482-524, 541-545, 556-564.

Supplemental Declaration of Dr. Gregory F. Welch

All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

Executed on August 8, 2024 in Longwood, Florida.



Dr. Gregory F. Welch