UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

META PLATFORMS, INC.,
Petitioner,

v.

EIGHT KHZ, LLC,
Patent Owner.

Case IPR2023-1021
Patent 10,917,737 B2

Case IPR2023-01022
Patent 11,172,316 B2

Case IPR2023-01023
Patent 10,798,509 B2

DECLARATION OF JOHN C. HART, PH.D.
IN SUPPORT OF PATENT OWNER'S PRELIMINARY RESPONSES

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I, John C. Hart, declare as follows:

I. INTRODUCTION

1. I have been retained as an independent expert consultant in the *inter partes* review ("IPR") proceedings involving the 10,917,737 Patent, the 11,172,316 Patent, and the 10,798,509 Patent by Eight kHz LLC ("8kHz"). I will refer to these patents using common shorthand. I have been asked to consider the arguments raised by the Petition regarding the validity of the '737 Patent, the '316 Patent, and the '509 Patent in this proceeding.

II. QUALIFICATIONS

2. I have been a professor of computer science, focusing on computer graphics including virtual reality systems, since 1992. I am currently a tenured Professor in the Department of Computer Science at the University of Illinois at Urbana-Champaign, a department consistently ranked in the top-5 by US News and World Report. I am also Director of the Office for Professional Education of the University of Illinois at Urbana-Champaign.
3. I received a Bachelor of Science degree in Computer Science from Aurora University in 1987, a Master of Science in Electrical Engineering and Computer Science from the University of Illinois at Chicago in 1989, and a Ph.D. in Electrical Engineering and Computer Science from the University of Illinois at Chicago in 1991.

4. I worked as an intern in 1998 at the IBM TJ Watson Research Center in Hawthorne, New York, and in 1999 at AT&T Pixel Machines in Holmdel, New Jersey. I worked as a postdoctoral research associate in 1991-1992 at the Electronic Visualization Laboratory at the University of Illinois at Chicago with funding from the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign. I worked as a visiting researcher in the summer of 2007 for the Graphics Research Group of Adobe Systems in Seattle, Washington.
5. From 1997-2000, I designed, simulated and patented graphics hardware for Silicon Reality and the Evans & Sutherland Computer Corp. I have also consulted for various visual effects companies (e.g., Kleiser-Walczak, Blue Sky | VIFX), defense contractors (e.g., SAIC, Pratt & Whitney) and medical imaging companies (e.g., Intrinsic Medical Imaging).
6. My research in computer graphics has been supported by Adobe, DARPA, Intel, Nokia, NVIDIA, NSF and Microsoft. I have published over 100 technical papers on computer graphics, including papers peer-reviewed, accepted and appearing in the most rigorous and prestigious publications in computer graphics, including the SIGGRAPH Annual Conference Proceedings, the ACM Transactions on Graphics, and the IEEE Transactions on Visualization and Computer Graphics.

7. The Association for Computing Machinery (ACM) is the main professional organization for computer scientists, and its special interest group on computer graphics and interactive techniques (SIGGRAPH) covers its efforts in computer graphics including virtual reality systems. From 2002 to 2008, I served as Editor-in-Chief of the ACM Transactions on Graphics, the top journal in the field of computer graphics. From 1996 to 2000, I served on the ACM SIGGRAPH Executive Committee, and in 1999 I served as Executive Producer for the production of its documentary "The Story of Computer Graphics." From 2014 to 2022, I served as the founding computer graphics area editor of the ACM Books series, and oversaw the publication of "The VR Book: Human Centered Design for Virtual Reality" (which is cited by Petitioners as Ex. 1033 of the IPR).
8. In 1992, I co-authored "The CAVE audio visual experience automatic virtual environment" which appeared in volume 35, issue 6 of the Communications of the ACM, and cited by over 2,600 subsequent publications on virtual reality systems. This was the seminal first paper describing the "CAVE," a room-sized virtual reality system where the walls and floor were projections screens, and head-tracking was used to ensure the images on these screens were rendered from the specific point of view of the occupant within its boundaries.

9. In 1993, I authored a subsequent paper "On recording virtual environments" which I presented at the IEEE Visualization '93 Symposium on Research Frontiers in Virtual Reality. In 2019, I co-authored "Real-time analytic antialiased text for 3-D environments" which won a best paper award when it was presented at the High-Performance Graphics Conference. This paper described how to render legible text for a head-mounted display in a virtual reality system.

III. BASIS OF OPINIONS

10. My opinions in this Declaration are based on my review of the '737 Patent, the '316 Patent, and the '509 Patent, their prosecution histories before the U.S. Patent and Trademark Office, the IPR Petitions concerning these patents, and references cited therein in support of the Petitions. I draw upon my experience and knowledge of acoustical engineering, psychoacoustics, signal processing, human-machine interaction, and virtual reality systems.

IV. RELEVANT LEVEL OF ORDINARY SKILL IN THE ART

11. In my opinion, as relates to the '737 Patent, the '316 Patent, and the '509 Patent, a person having ordinary skill in the relevant art (a POSITA) would have several years of academic and/or professional experience in a technical field relevant to digital audio signal processing, such as electrical engineering, computer engineering, or computer science; and a familiarity

with relevant literature and concepts concerning virtual "3D" audio processing, which were widely available at the time of disclosure.

12. I am at least a POSITA under this definition. My training and experience in computer science, computer graphics and virtual reality systems has included such digital audio signal processing. The field of computer graphics has included publications on audio, including the use of "sonification" as an auditory supplement for data visualization. The simulation of audio wave propagation is also analogous to the radiative light wave simulations used for photorealistic rendering. The use of transfer functions, such as a head-related transfer function (HRTF) for perceiving binaural audio, is also common to computer graphics, which includes the precomputed radiance transfer function (BRTF) for perceiving binocular light. A true and accurate copy of my CV is attached to the Patent Owner Preliminary Response as Exhibit 2002.

V. The '737 Patent

13. The '737 Patent is generally directed to using a handheld portable electronic device to define a zone around a user wearing a wearable electronic device.

VI. Claims of the '737 Patent

14. I understand that Petitioner challenges claims 1-20 of the '737 Patent, including the three independent claims, claims 1, 8, and 14.

1. A method executed by one or more electronic devices, the method comprising:

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

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

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

processing, by a processor, sound with head-related transfer functions (HRTFs) to generate the binaural sound that externally localizes to the user at the location of the SLP in empty space in the zone above the physical floor; and

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

8. A method executed by one or more electronic devices, the method comprising:

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

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

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

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

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

14. An electronic system, comprising:

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

a wearable electronic device (WED) that is worn on a head of the user, tracks movement of the PED to determine the boundary of the 3D zone that

extends from the physical floor and around the user, includes a processor that processes sound with head-related transfer functions (HRTFs) so sound externally localizes as binaural sound to the user at the SLP in empty space inside the 3D zone defined by movement of the PED, and displays a virtual image at the SLP in empty space inside the 3D zone, and displays a 3D virtual image that shows the boundary of the 3D zone that extends from the physical floor and around the user.

VII. The '316 Patent and '509 Patents

15. The '316 Patent and the '509 Patent share a common specification. For convenience and efficiency, in this section VI, I refer to and cite to the specification of the '316 Patent, but this same disclosure is found in the '509 Patent.

16. Through various embodiments, the '316 Patent is generally directed to dividing an area around a user into a three-dimensional zone using a portable electronic device. The zone contains sound localization points (SLPs) from where binaural sound originates to the user. The zone is created using a portable electronic device (PED) held in the user's hand, as shown in Figures 9A to 10D, for example.

17. The '316 Patent discloses example methods of tracking the location of a handheld controller (HPED), including using a wireless electromagnetic motion tracker, a system using active markers or passive markers, a markerless motion capture system, a radio frequency system, an infrared

motion capture system, or tracking a HPED with a tag or barcode, radio frequency identification tag and reader. 22:22-34; 32:5-16.

18. The '316 Patent discloses example methods of tracking the location of a handheld controller (HPED), including using a wireless electromagnetic motion tracker, a system using active markers or passive markers, a markerless motion capture system, a radio frequency system, an infrared motion capture system, or tracking a HPED with a tag or barcode, radio frequency identification tag and reader. 22:22-34; 32:5-16.

19. The '316 Patent discloses that when the HPED is not within the pre-defined zone, an action occurs. For example, the HPED may be located in an area that does not include a zone. When the HPED is not within the pre-defined zone, example actions include displaying a visual indication of the zone or zones so the user can move to or navigate to the zone. 19:64-20:27. The '316 Patent also provides that the "zones and SLPs can also be mapped to provide a user with a 2D or 3D visual indication of the zones and a location of the SLPs in the zones. For example, the HPED displays an image of the zones and where the SLPs are located in each zone." 20:53-59.

VIII. Claims of the '316 Patent and '509 Patent

20. I understand that Petitioner challenges claims 1-20 of the '316 Patent, including the three independent claims, claims 1, 9, and 17.

1. A method comprising:

dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a zone that extends around the user and that includes a sound localization point (SLP) from where binaural sound in empty space originates to the user;

playing, with speakers in a wearable electronic device (WED) worn on a head of the user, the binaural sound that originates from the SLP in empty space;

tracking, with one or more sensors in the WED worn on the head of the user, the PED to determine when the PED held in the hand of the user is moving outside the zone that extends around the user; and

displaying, with the WED worn on the head of the user, a virtual reality (VR) image that shows the zone in response to the WED determining that the PED is moving outside the zone.

9. A method comprising:

dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a three-dimensional (3D) zone that extends around the user and that includes sound localization points (SLPs) from where binaural sound originates to the user;

determining, with a wearable electronic device (WED) worn on a head of the user, when the user is leaving the zone; and

warning the user that the user is leaving the zone by displaying, with the WED worn on the head of the user, a 3D virtual reality (VR) image of the zone in response to the WED determining that the user is leaving the zone.

17. An electronic system comprising:

a portable electronic device (PED) held in a hand of a user that divides an area around the user into a three-dimensional (3D) zone that extends around the user and includes sound localization points (SLPs) in empty space from where binaural sound originates to the user while the user is located inside the zone; and

a wearable electronic device (WED) that is worn on a head of the user, wirelessly communicates with the PED, includes speakers that play to the user the binaural sound that emanates from the SLPs in empty space inside the zone, includes one or more sensors that sense when the PED is leaving the zone, and includes a display that displays a virtual reality (VR) image of the zone in response to sensing that the PED is leaving the zone, wherein the display displays the VR image of the zone to warn the user that the user is leaving the zone.

21. Each of these claims includes a required element that displays an image of the zone that occurs when the WED, PED or user is leaving, or is moving outside of, the zone. This functionality is well described by the '316 Patent at 20:9-11, stating "displaying a visual indication of the zone or zones so the user can move to or navigate to the zone and correct location."

22. I understand that Petitioner challenges claims 1-14 and claims 17-20 of the '509 Patent, including the three independent claims, claims 1, 9, and 17.

> 1. A method comprising:
>
> dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a zone that includes multiples sound localization points (SLPs) from where binaural sound originates to the user;
>
> determining, with a wearable electronic device (WED) worn on a head of the user, when the user is located inside the zone;
>
> 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; and
>
> 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.
>
> 9. A non-transitory computer readable storage medium storing instructions that one or more electronic devices execute as a method, the method comprising:

dividing, with a portable electronic device (PED) held in a hand of a user, an area around the user into a zone that includes sound localization points (SLPs) in empty space from where binaural sound originates to the user;

determining, with a wearable electronic device (WED) worn on a head of the user, when the user is located inside the zone;

determining, with the WED worn on the head of the user, when the user is leaving the zone; and

displaying, with the WED worn on the head of the user, a three dimensional (3D) virtual image of the zone in response to the WED determining that the user is leaving the zone.

17. An electronic system comprising:

a portable electronic device (PED) held in a hand of a user that divides an area around the user into a three-dimensional (3D) zone that includes sound localization points (SLPs) in empty space from where binaural sound originates to the user; and

a wearable electronic device (WED) that is worn on a head of the user, wirelessly communicates with the PED, includes speakers that play the binaural sound to the user that emanates from the SLPs in empty space, includes one or more sensors that sense when the PED leaves the zone, and includes a display that displays a 3D virtual image of the zone in response to sensing that the PED leaves the zone, wherein the display displays the 3D virtual image of the zone to warn the user that the user is leaving the zone.

IX. GROUND 1 OF THE PETITIONS: PEDROTTI WITH JANG AND BEGAULT

23. Petitioner uses U.S. Patent No. 9,851,786 to Pedrotti ("Pedrotti"), U.S. Patent No. 8,520,872 to Jang ("Jang"), and Durand R. Begault, *3-D Sound for Virtual Reality and Multimedia*, NASA/TM—2000-209606 (Aug. 2000) ("Begault") in support of its obviousness challenge. Petitioner has mischaracterized teachings of Pedrotti.

A. Pedrotti

24. Pedrotti is entitled "System and Method for Assisting a User in Remaining in a Selected Area While the User is in a Virtual Reality Environment." One embodiment in Pedrotti is directed to defining a "safe area" in the physical world that is free from physical obstacles. The "processor" in Pedrotti then causes the head-mounted display (HMD) to display a warning, such as a virtual fence, to alert the user if the user approaches within a preselected distance of the boundary. Abstract.

25. Pedrotti discloses that while the user is wearing the HMD and in the virtual world, the user is unable to see physical objects in the physical world. Pedrotti at 2:21-26. For example, Pedrotti provides that "FIG. 1A shows a user 102 in the real world wearing a HMD 106; HMD 106 covers the user's eyes and presents the user with a representation of a virtual world, while preventing the user from seeing the real, or physical, world."

Pedrotti at 4:45-48. Because the user cannot see the physical world while wearing the HMD and in the virtual world, Pedrotti discloses that the user may define a boundary to determine a "'safe area' which the user or another person has determined is clear of physical obstacles in the physical world so that the user may move freely without coming into contact with such physical obstacles." Pedrotti at 4:32-36.

26. Pedrotti discloses several different methods for the user to define the boundary of the "safe area." One such method is for the user to input information into the processor "indicating that there is a circular area in front of the base station and having a measured diameter that is clear of objects" as illustrated in FIG. 12. Pedrotti at 14:6-12. Another method is for the user to define an irregularly shaped "safe area" by "having the user walk around a perimeter chosen by the user with one of the trackers to define the outer boundary of a selected area, for example, one in which there are no obstacles." Pedrotti at 14:56-62. Pedrotti provides that the processor determines the position of the tracker at a number of sampling points as the user moves around the chosen perimeter, and from those points, the processor determines the boundary 1404. Pedrotti at 14:62-65.

27. To determine the user's position within the "safe zone," Pedrotti discloses using trackers that can be a part of the HMD and on handheld controllers.

Pedrotti discloses that these trackers communicate with a base station and position is determined using known tracking techniques. For example, the trackers may sense an electromagnetic field generated from the local base station or video game console and the tracker provides information about the sensed magnetic field to "a processor" that derives the position and orientation of the tracker and thus HMD relative to the base station, which is the "source of the electromagnetic field." Pedrotti at 4:49-5:24.

B. Jang

28. Jang is entitled "Apparatus and method for sound processing in a virtual reality system." Through its title is quite general, Jang's disclosure focuses on the concept of "sound areas" such that the "audio, sound and/or other sensory data" used to "represent the virtual environment" to a user are divided into "a focus area and non-focus areas." Jang uses this division of the sound data to process sounds in the focus area differently than sound data in the non-focus areas. For example, this difference in processing sounds by area might cause "audio elements of the non-focus areas to be muffled or quieter than audio elements of a focus area." Jang at 6:39-59.

29. Jang discloses virtual reality devices and apparatuses that all include, among other units, a control unit and a sensory processing unit. See e.g. Jang at 6:27-28. The control unit receives "virtual reality space

information," accesses audio, sound and/or other sensory data," controls "the sensory data to correspond to the virtual environment," mixes "sensory data of the virtual environment including a user's avatar or character and other avatars, characters, objects, or features of the virtual environment," divides "the sensory data into a focus area and non-focus areas," and controls "the sensory processing unit … to output sensory elements of the focus area differently than sensory elements of the non-focus areas." Jang 6:39-59. The sensory processing unit prepares audio and visual sensory data for presentation to the user via an output device. See e.g. Jang at 7:3-7.

30. Jang discloses the division of a virtual reality space in the context of "a character, or actor, … of the user of the virtual reality apparatus." Jang at 8:21-22. Jang discloses that this virtual reality space is divided "into a focus area within the visual field of the character using the virtual reality apparatus and non-focus areas outside the visual field." Jang at 8:26-28. "[T]he control unit … divides the sound area of the virtual space into a focus area and non-focus areas." Jang at 9:46-47.

C. A POSITA Would Not Be Motivated to Combine Pedrotti with Jang

31. Dr. Welch at Section X.A.1. erroneously opines that a POSITA would have been "motivated to combine Pedrotti's system and method for assisting a user in remaining within a selected area with Jang's sound processing methods." I disagree. All of the paragraphs, except ¶213, of this section opine that Pedrotti and Jang disclose inventions in the area of VR, and these inventions could use similar HMD and other VR equipment. These arguments are so general that they would lead to the preposterous conclusion that any combination of VR disclosures would be obvious.

32. Dr. Welch at ¶213 opines that a POSITA "would have been motivated to incorporate the teachings of Jang into Pedrotti's system in order to enable the user to experience the full breadth of the virtual world, even with physical constraints imposed by Pedrotti's 'safe area.'" "[b]ecause Pedrotti's teachings limit the user's physical movements to within a 'safe area'" whereas "Jang teaches how to navigate a virtual reality space without needing to walk in the virtual world the same distance the user would have to walk in the physical world." Jang did not invent the ability to use an input device to transport a user virtually to a space without physically moving to that space, and a POSITA would have had the benefit of the wealth of spatial navigation techniques from the decades of

videogames that use a mouse of joystick for navigation instead of physical tracking of the user. Dr. Welch at ¶213 mischaracterizes Jang as disclosing a new ***method*** and user ***interface*** for "space shift," when Jang quite clearly does not, and instead discloses methods for ***detecting*** and ***responding*** to a space shift by altering the resulting sensory output of the sensory data.

33. Since Jang offers no benefit to Pedrotti because its "space shift" approach was already well known in the spatial navigation of virtual environments, a POSITA implementing Pedrotti would not be motivated to utilize Jang in any combination with Pedrotti. Using spatial navigation to justify the incorporation of Jang's sound processing into Pedrotti's non-audio invention is a hindsight directed by the claims of the '319 Patent.

1. Pedrotti and the claims of the '316 Patent and '509 Patent "dividing … an area around the user into a zone"

34. I disagree with the Petitioner's assertion that "Pedrotti's handheld controller (PED) divides an area around a user into a zone – Pedrotti's 'selected' or 'safe' area in VR, bound by Pedrotti's boundary and its virtual fence." Pedrotti's boundary-defining techniques fail to teach or suggest dividing, with a PED held in a hand of a user, an area around the user into a zone. That is, by having the user walk around a perimeter with a tracker, Pedrotti merely identifies sampling points adjacent to the user while the

PED is held in the hand of the user. Pedrotti, 14:56-65. In this way, Pedrotti may use the PED to establish some boundary, but the boundary is not around a user, while the user is holding the PED.

35. In addition, Pedrotti's user is only collecting sampling points adjacent to the user and never collects sampling points around the user to divide an area into a zone that extends around the user. Put simply, the boundary defined by Pedrotti's user walking with the PED never extends around a user.

2. "tracking, with one or more sensors in the WED … the PED" / "determining with the WED … when the user is leaving the zone"

36. Pedrotti discloses a stationary base station that includes a processor, which is external to the HMD, that tracks the position of trackers in the HMD and in the handheld controller with respect to the position of the base station. Pedrotti, 5:30-33.

All of Pedrotti's teachings on tracking involve the stationary base station. Pedrotti teaches that whether by electromagnetic fields, light emitting trackers, or other forms, the HMD and handheld controller is tracked in relation to their distance from a base station. *Id.* 4:49-58, 5:7-24.

Specifically, Pedrotti repeatedly teaches that all tracking of both the HMD and the handheld controller is performed in relation to a "base station,"

game console, or other device, which is outside the HMD. *See, e.g.*, Figure 14, reproduced above, showing base station 1402.

37. Tracking the handheld controller with Pedrotti's HMD, when worn on the head, to define a safe area is directly contrary to Pedrotti's teachings emphasizing the safety of the user by avoiding collisions with physical obstacles in the safe area. The system disclosed in Pedrotti determines when the controller is moving outside the pre-defined "safe area" boundary based on a tracked position of the controller relative to a stationary location (e.g., base station), not the HMD or sensors on the HMD. When the user is wearing Pedrotti's HMD, the user cannot see the physical world and thus cannot safely define the safe area. Once the user is wearing the HMD, the *user cannot see* the physical world to navigate the chosen perimeter and avoid physical obstacles. Indeed, Pedrotti states, once the user "has donned the HMD, [the] user can no longer see the surrounding physical world" and cannot see the location of any physical obstacles. *Id.* 1:30-33, 6:23-25 (quoted), 11:52-55, 12:28-30. Petitioner's position, which would have a user walking in the physical world but unable to see any physical obstacles is contrary to the explicit teachings in Pedrotti of methods to avoid collisions with physical obstacles. Therefore, it is clear that the Pedrotti system does not envision and, indeed, cannot provide controller

tracking via a processor of the HMD and thus, does not teach or suggest handheld controller tracking by an HMD (WED) worn on the head of the user.

38. In context, Pedrotti's statement that a processor may be located "even in the HMD," merely remarks that a ***processor***, not a ***tracker***, may be located in virtually any devices associated with the system to perform any number of "different functions of the functions described herein." Pedrotti, 16:20-22. For example, the processor in the HMD may perform a function such as 3-D scene rendering. See, e.g., id. 2:36-38 ("generating and outputting, by the processor, instructions to the HMD to display on the HMD a virtual world").

39. Pedrotti teaches away from using an integrated tracking system wholly within the HMD, stating,

> 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 the base station can be determined.

6:3-10.

40. Pedrotti's tracking system depends on the presence of the stationary base station, which determines the positions of the HMD and the handheld

controllers relative to this fixed reference point. A POSITA would have understood that without such a fixed reference point, a tracking system would suffer from drift due to the accumulation of small tracking errors.

41. Dr. Welch at ¶¶600-602 opines that "Pedrotti … discloses, or at a minimum renders obvious, tracking 'with one or more sensors in the WED'" by suggesting that it would have been obvious for "tracking capabilities to be wholly contained in an HMD." Dr. Welch seeks support for this position by pointing to his summary in Section VII.D "describing all-in-one and inside out tracking." But Dr. Welch states in Section VII.D as a "principle" that "to track the pose of a user's head with sensors (e.g., cameras or microphones) and sources (e.g., LEDs or speakers), one can ***either*** put the sources on the user's **moving** head and then mount sensors at ***fixed points*** in the environment, ***or the reverse***—put the sensors on the user's **moving** head and mount sources at ***fixed points*** in the environment." Welch Decl. at ¶87, emphasis added. Thus, it would not have been obvious for "tracking capabilities … wholly contained in an HMD" to be able to track a ***moving*** PED from a ***moving*** HMD.

3. "displaying … a virtual reality (VR) image that shows the zone in response to the WED determining that the PED is moving outside the zone" / "displaying, with the WED … a 3D virtual image of the zone" in response to determining/sensing the user is leaving the zone

42. Pedrotti discloses displaying a virtual fence when the user's head or hands are approaching the boundary. From this, Dr. Welch erroneously concludes that "This 'grid' or 'virtual fence' is, or at a minimum obviously could be, a virtual image appearing at Pedrotti's zone boundary that shows the size and shape of Pedrotti's zone."

43. Pedrotti does not disclose displaying a virtual fence or any other representation when the user is moving outside or leaving the safe area that Dr. Welch identifies as the zone required by the '316 claims.

44. With regard to the user's head or hands moving outside the zone, Pedrotti describes providing additional messaging or warnings such as causing the HMD "to fade to black, and present, for example, only a warning message." Pedrotti, 13:63-14:5. Pedrotti does not disclose that this additional messaging or warning includes a virtual fence indicative of the "safe area." Thus, Pedrotti actually teaches away from displaying a three-dimensional virtual image of the zone in response to determining that the user is leaving the zone.

45. Pedrotti's virtual fence presented when the user approaches the boundary does not show the zone that extends around the user. Pedrotti discloses that the virtual fence is rendered in a minimal manner to provide for optimal processor performance. Id. That is, to preserve processing power

related presenting the virtual fence, Pedrotti presents just a portion of the virtual fence adjacent to the area in which the user is approaching, not showing the entire zone.

4. Highlighting One of the SLPs when Pointed to by the Hand-Held PED

46. Petitioner relies upon Pedrotti's disclosure that its virtual fence "can be glowing or colored if desired to be more visible," to teach the concept of highlighting. However, Pedrotti's virtual fence is not a sound localization point and thus does not teach or suggest "highlighting… one of the multiple SLPs."

47. Petitioner asserts that Pedrotti renders this claim limitation obvious, specifically citing disclosure that Pedrotti's controllers (PEDs) manipulate and control virtual objects in VR and suggesting that the pointing pattern is often used for selection. Pedrotti, however, is silent regarding "selection" of SLPs, as described above. Further, as illustrated in FIGS. 1A and 1B of Pedrotti, Pedrotti's "virtual object" is a virtual representation of the controller, not an SLP that the controller can point to. Indeed, as a virtual representation of the controller, it is impossible to point the controller to the virtual object, which is itself.

48. Thus, Petitioner has mischaracterized the manipulation and control of the "virtual objects" described in Pedrotti, construing these objects as items

that can be "selected" and then bridging the selection to a statement not found in the references that the pointing pattern is often-used for selection.

X. GROUND 2 OF THE PETITIONS: MCCULLOCH WITH PEDROTTI AND FLAKS

49. Petitioner uses U.S. Patent No. 9,041,622 to McCulloch ("McCulloch") with Pedrotti and U.S. Patent No. 8,767,968 to Flaks ("Flaks") in support of its obviousness challenge. Petitioner has mischaracterized teachings of McCulloch.

A. McCulloch

50. McCulloch is entitled "Controlling a Virtual Object with a Real Controller Device" and is generally directed to a near-eye, augmented reality display that displays virtual objects the user can control with a real controller device, such as a joystick or touchpad. While McCulloch discloses displaying virtual objects, it does so on an augmented reality ("AR") display that is see-through, meaning the user is able to see the physical world at all times while wearing the HMD. Id. at 3:54-4:3. McCulloch further explains that real controller devices can also enhance realism with AR devices as they can provide sensory feedback. Id. at 1:29-33.

51. For example, McCulloch discloses a virtual remote control helicopter may be displayed in the near-eye, augmented reality display device, such

as a pair of glasses. The real controller device has a joystick that the user manipulates to control the position of the virtual remote control helicopter, such as moving the virtual remote control helicopter to the right, as discussed in connection with Figures 3A and 3B.

52. McCulloch teaches how to use user inputs from real controller devices to control virtual objects and leverage feedback mechanisms in the real controller devices to enhance the immersive experience for the user. Id. at 6:61-66. To further the user's immersive experience, McCulloch teaches how to use eye tracking, gaze data, and hand gestures to select virtual objects or virtual representations of real objects for control with the real controller device without requiring the user to select the virtual object using the real controller device. Id. at 13:42-45.

53. McCulloch emphasizes bringing a more immersive experience to users through the use of force feedback in a real controller device and the use of an AR display to seamlessly blend the real world with virtual elements. *Id*., 4:34-39.

54. McCulloch discloses that a gaming application may receive user input defining boundaries for a "playspace" in which virtual objects, such as the virtual remote control helicopter, can be positioned. The "playspace" of McCulloch defines the boundaries of where the virtual objects can be

positioned in the user's field of view, and may be automatically determined based on a 3D mapping of the user environment or location.

55. McCulloch focuses on controlling virtual object features within a display field of view or a display portion of what a user looks through and is seen from the user's perspective. 4:4-13. The display field of view is defined in terms of some coordinate system that may be acquired using 3D mapping techniques with image data and depth data. Id., 11:56-12:17; 15:1-62. As such, the display field of view in McCulloch is only related to the user's perspective view – not a virtual boundary or zone that extends around the user. Because the boundaries of the playspace are defined by the user's field of view, such boundaries change based on the user's present environment. There is no teaching in McCulloch of a "safe area," or to keep the boundaries the same, or to keep the user within the fixed boundaries of the "safe area," as taught in Pedrotti.

56. McCulloch does not describe a situation in which the user is within the display field of view because McCulloch is directed instead to augmented reality (not virtual reality) where a user can position virtual objects within a playspace within the user's view. Id., 20:4-18.

57. Because the HMD in McCulloch allows the user to see the physical world, there is no need for McCulloch's playspace to be used in helping

the user avoid collisions with physical objects. A user of McCulloch's system does not move the real controller device in an environment to assist a user to stay within a designated safe space when the user's eyes are covered by a head mounted display (HMD) by displaying a visual boundary in virtual space to the user when the user approaches the boundary of the safe space in reality. Because the AR display of McCulloch is a see-through device and because the user controls virtual objects only viewable in front of the user with the real controller device, the user in McCulloch is always able to view the user's surroundings to operate a safe space.

58. Controller position tracking (e.g., relative to a zone) is unnecessary in the context of McCulloch's claimed invention.

59. Thus, I do not agree with Petitioner's argument that a POSITA would combine McCulloch and Pedrotti. Because the boundaries of the playspace in McCulloch changes based on the present environment, a POSITA would never look to incorporating McCulloch's relative positional tracking techniques employed for its controllers to determine whether the controller is leaving a "safe area" as disclosed by Pedrotti. In addition, in contrast to the HMD in McCulloch, the HMD of Pedrotti blocks the view of the user. Pedrotti, 11:43-55. Pedrotti desires to keep

users within a selected area to allow the users to move while the user sees "only the virtual world." *Id*., 1:57-60. The user in McCulloch, however, is not physically moving in the physical world. In view of the completely distinct types of HMDs used in McCulloch and Pedrotti, and the different aims of each, a POSITA has no practical reason to combine these two references.

60. The hypothetical scenario Petitioner constructs, a person tripping over a sofa while flying a virtual helicopter, actually demonstrates why a POSITA would not be motivated to implement Pedrotti as an improvement to McCulloch. Pet. 47. McCulloch's focus on bringing a more immersive experience to users invokes concepts like force feedback in a real controller device and the use of an AR display to seamlessly blend the real world with virtual elements. The creation of a virtual safety fence is not only counter to the objectives of the McCulloch invention, but also unnecessary. First, McCulloch describes an invention that is meant to blur the lines of reality and fiction like as described in Fig. 8D where the user throws a virtual basketball at a real television and the HMD displays a simulated occluding image of the television being damaged. McCulloch, 29:36-63. If the user was approaching a couch and a virtual wall were to

suddenly appear, this would serve as sudden and violent break with the immersive experience McCulloch is trying to create.

61. Furthermore, beyond the fact that a user would be able to see the couch wearing the McCulloch HMD in Petitioner's hypothetical, McCulloch specifically teaches using depth sensors on the HMD and other parts of the system to produce a 3D map of the objects in the user's environment. McCulloch also teaches how that depth data and object mapping is used to i) avoid improper visual occlusions between real world and virtual objects, ii) track the HMD within the environment, and iii) track the gaze of the user. Using the object map, McCulloch teaches that its HMD can easily predict a potential collision with a physical object, know whether the object is seen by the user, and alert the user to the presence of the object if necessary.

62. A POSITA would not be motivated to combine McCulloch's boundary setting method with the Pedrotti boundary method. The boundary method described in McCulloch uses only eye tracking and gaze information when establishing the boundary. This method is reliant on a device that permits the user to see the real world. In contrast, the Pedrotti invention is targeted for a device that *obscures* the real world, where eye tracking and gaze data would not be helpful in identifying a boundary in the real world, and

instead relies on positional tracking. The McCulloch teaching is incompatible with the Pedrotti device and methods.

1. McCulloch and the claims of the '315 Patent and the '509 Patent, "dividing … an area around the user into a zone"

63. I disagree with Petitioner's assertion that McCulloch teaches controller tracking with an HMD. Pet. at 49. McCulloch uses an inertial motion unit to provide speed, acceleration, and directional data, not positional data. In addition, McCulloch discloses that selecting the virtual object is not a function of HPED tracking but eye tracking. Pet. at 50; McCulloch, 4:25-31, 28:63-66, 29:4-63.

64. The inertial motion sensors in McCulloch provide relative motion data to control virtual objects presented in the field of view for the user. The real controller device of McCulloch cannot be used to provide positional data to divide an area around a user into a zone that extends around the user.

2. "tracking, with one or more sensors in the WED … the PED" / "determining with the WED … when the user is leaving the zone"

65. Any tracking of the real controller device performed by the HMD (AR glasses) of McCulloch is for the purpose of controlling a virtual object in a field of view based on inertial movements of the controller – not relative position of the controller with respect to a zone.

66. The sensors of McCulloch may, at best, track a relative distance between the HMD and the controller – not a position relative to a zone previously defined by the PED.

67. 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. McCulloch, 29:4-17. As such, any 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 – not relative position of the controller with respect to a zone.

68. While McCulloch does disclose a "location sensing unit 144," this unit identifies a physical location of the user, not a location of the user with respect to a virtual boundary, and thus would not be obvious to combine with Pedrotti's virtual safe area. Indeed, the location sensing unit in McCulloch is described as including a "GPS transceiver, an infrared (IR) transceiver, or a radio frequency transceiver for processing RFID data." McCulloch, 8:17-22.

69. Dr. Welch at ¶740 opines erroneously that "McCulloch teaches that its controllers are tracked relative to the HMD and surrounding environment

using image and depth data." Dr. Welch cites McCulloch at 7:34-59 which only discloses the capabilities of the "capture devices" which acquire "depth data and image data" to form a "depth map of the captured field of view of the capture devices" and generate a "three dimensional (3D) mapping of the display field of view." This passage mention neither the capture nor the detection of the controllers, which may or may not lie within the "captured field of view of the capture devices." Dr. Wlech further cites McCulloch at 8:17-30 which only discloses the capabilities of the "head-mounted display device" and do not disclose anything regarding the hand-held controllers.

70. Dr. Welch at ¶740 further opines, also erroneously, that "McCulloch also discloses tracking the translation and rotation of the handheld controller, e.g., the handheld IMU real controller device 19, via its inertial sensors. A POSITA would have understood that the determination of absolute position from the continuous accumulation of relative impulses from the inertial sensors would also suffer from the accumulation of error and would produce an ineffective and inaccurate tracking of absolute position. Dr. Welch further opines that a POSITA "would have understood that determining the handheld IMU device was being moved 'in the direction of the television 16 [such] that the virtual basketball 303 collides with the

display of the television' as disclosed by McCulloch ((Ex.1008) at 29:44-46) would ***require*** the dynamic determination of the ***position*** and orientation of the handheld IMU device relative to the McCulloch's HMD and the world." Dr. Welch at ¶741, emphasis added. But the Figures 8A-D that this passage of McCulloch describes show the basketball and the controller to be in ***two disjoint positions***. Dr. Welch does not clarify whether the position of the basketball or the position of the controller would be required for the example. Instead, Figures 8A-D show clearly that McCulloch teaches that its invention neither needs nor uses the absolute position of its controllers, and works will using only the relative changes in position reported by the controller's inertial sensors.

3. "displaying … a virtual reality (VR) image that shows the zone in response to the WED determining that the PED is moving outside the zone" / "displaying, with the WED … a 3D virtual image of the zone" in response to determining/sensing the user is leaving the zone

71. McCulloch never describes displaying a VR image of the zone or displaying the VR image of the zone in response to determining that the user/PED is moving out of the zone. McCulloch always presents the playspace in which virtual objects appear in front of the user wearing the augmented reality device.

72. Boundary points may also be captured based on the user's gaze, as detected by the capture device. Id. However, these boundary points are not presented to the user in McCulloch. Instead, a 3D mesh used to represent a mapping of an environment surrounding the user is used to automatically determine a playspace for a gaming application. Id., 20:18-25. Otherwise, the only other boundary data depicted in McCulloch is object boundary data that includes edge data or polygon mesh for a real or virtual object – not a zone or playspace area. Id., 19:14-21. Indeed, the only instance in which McCulloch mentions that the user may not view the display field of view, McCulloch describes a collision of a virtual object that may occur outside of the display field of view and a physics engine may perform still perform collision modeling on the virtual object despite it being outside of view. Id., 27:42-51. As such, in the only instance that McCulloch describes something leaving the playspace, McCulloch does not create any notification, much less a VR image, related to the playspace area.

XI. CONCLUSION

73. I declare that all statements made herein of my knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with knowledge that willful false

statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code. I reserve the right to modify my opinions as additional information becomes available to me.

Dated: October 11, 2023 By: _____