

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VALVE CORPORATION,
Petitioner,

v.

IMMERSION CORPORATION,
Patent Owner.

Patent No. 10,665,067

DECLARATION OF GREGORY F. WELCH, PH.D.

Valve Exhibit 1003 Valve v. Immersion
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I, Gregory F. Welch, Ph.D., declare:

1. I have been retained on behalf of Valve Corporation (“Valve” or “Petitioner”) as an independent technical expert in the above-captioned IPR proceeding (“the IPR”). This document provides certain of my opinions concerning the patentability of claims in U.S. Patent No. 10,665,067 (“the ’067 patent”), specifically claims 1-8, 11-12, and 15-21 (the “Challenged Claims”). I make this Declaration in support of Valve’s petition in the IPR.

2. For my work as an expert in this matter, I am being compensated for my services at a rate of \$600/hour, plus actual expenses. My hourly compensation is based solely on the amount of time that I devote to activity related to this case and is in no way contingent on the nature of my findings, the presentation of my findings in testimony, or the outcome of this or any other proceeding. I have no other personal or financial stake or interest in the outcome of the present proceeding. I do not have any expectation or promise of additional business with the Petitioner in exchange for the positions explained herein.

3. I make this Declaration based on my personal knowledge, including my education, training, research, and professional experience.

I. PERSONAL AND PROFESSIONAL BACKGROUND

4. My curriculum vitae (“CV”) detailing my educational background, professional experience, and list of publications is provided as EX1004. For ease of reference, I have highlighted certain information below.

5. I received my B.S. degree in Electrical Engineering Technology from Purdue University (with *Highest Distinction*) in May 1986, my M.S. in Computer Science from the University of North Carolina at Chapel Hill in May 1995, and my Ph.D. degree in Computer Science from the University of North Carolina at Chapel Hill in May 1997.

6. I am currently a Pegasus Professor and the AdventHealth Endowed Chair in Healthcare Simulation at the University of Central Florida (“UCF”) with appointments in the Computer Science Department in the College of Engineering & Computer Science, the Institute for Simulation and Training in the School of Modeling, Simulation, and Training, and the College of Nursing. I began teaching at UCF in 2011. In 2020, I was awarded a Pegasus Professor Award by UCF, the highest academic award a professor can receive at UCF, recognizing faculty excellence in teaching, research, and service.

7. Previously I have been a Research Professor and Adjunct Professor at the University of North Carolina at Chapel Hill. I also was a Senior Engineer at Northrop-Grumman’s Defense Systems Division where I worked on the AN/ALQ-

135 electronic countermeasures system for the U.S. Air Force F-15 Eagle aircraft. And I was also a member of the technical staff of NASA's Jet Propulsion Laboratory where I worked on the Voyager Spacecraft project.

8. My current research interests include human-computer interaction, virtual and augmented reality, human motion tracking systems, three-dimensional (3D) telepresence, projector-based graphics, computer vision, and medical applications of computers for training, assessment, and practice in domains such as healthcare and defense. I have co-authored over 200 peer-reviewed publications in these areas — one with over 11,500 citations, and I am a co-inventor on 26 issued patents. I currently supervise over \$7 million in research funding and am jointly responsible for over \$35 million in grants overall since 1996. Examples of grantors for my research include the Office of Naval Research (ONR), the National Science Foundation (NSF), The National Institutes of Health National Library of Medicine (NIH-NLM), the Defense Advanced Research Projects Agency (DARPA), the Department of Energy (DOE), and private companies—all involving multi-disciplinary and multi-institutional projects.

9. I have co-chaired major academic conferences. For example I am presently co-chairing the IEEE Virtual Reality conference to be held in Orlando (FL) in March, 2024. I recently co-chaired EuroXR 2023 in Rotterdam (NL), and previously the International Symposium on Mixed and Augmented Reality in 2012

and the IEEE Virtual Reality conference in 2013. I have also co-organized multiple international workshops and research retreats in these areas. I have served on numerous program committees, co-chaired workshops, and serve as a peer reviewer for many conferences and journals. I am an Associate Editor for the journal *Presence: Virtual and Augmented Reality* and an Associate Editor for the journal *Frontiers in Virtual Environments*.

10. I am a Fellow of the Institute of Electrical and Electronics Engineers (“IEEE”), a Fellow of the National Academy of Inventors (“NAI”), an inaugural member of the IEEE VGTC Virtual Reality Academy, a member of the Association for Computing Machinery (“ACM”), an ACM Special Interest Group on Computer Graphics and Interactive Techniques (“SIGGRAPH”) Pioneer, a member of the International Virtual Reality Healthcare Association, a member of Vision Sciences Society (“VSS”), a member of European Association for Computer Graphics (“Eurographics”), a member of the Southern Nursing Research Society (“SNRS”), a member of the International Nursing Association for Clinical Simulation & Learning (“INACSL”), and a member of the Society for Simulation in Healthcare (SSH).

11. My personal awards include the IEEE and NAI Fellow elevations (above), the IEEE VGTC Virtual Reality Technical Achievement Award in 2018, a UCF Luminary Award in 2017, a UCF Research Incentive Award in 2017, an

ISMAR Rock StAR Award in 2016, and an Excellence in Teaching Award at UNC in 2007. Shared awards include multiple awards for papers and demos. With co-authors Prof. Ramesh Raskar, Prof. Henry Fuchs, and Deepak Bandyopadhyay I was awarded the Long Lasting Impact Paper at ISMAR 2016.

12. As a computer scientist and engineer, my activities and expertise span both software and hardware, including software systems and interfaces. Much of my academic work since the early 1990s has focused on research and associated development related to human-computer interaction, including real-time and on-line human motion sensing, input and output controls, signal processing, and motion-related event processing, employing a variety of hardware systems including a various sensors, input and output devices, general purpose computers, embedded systems, and custom circuitry.

13. A prime example is the HiBall Tracking system that I co-developed in the 1990s. The system served to track the six degrees-of-freedom (6DOF) position and orientation of a target such as a head, hand, or handheld device in a three-dimensional (3D) space. The HiBall Tracking system is an implementation of my Ph.D. work at UNC in the mid-1990s, where I introduced a new approach to sense and track a user's position and orientation using a sequence of single sensor measurements, described in my Ph.D. dissertation titled "SCAAT: Incremental Tracking with Incomplete Information." A key realization for this approach is that

the single sensor observations provide some information about the user's state, and thus can be used to incrementally improve a previous estimate. By recursively applying this principle, incorporating new sensor measurement data as soon as it is measured, a user's pose can be estimated more frequently, with less latency, and with improved accuracy.

14. I have incorporated tactile feedback in multiple research projects. A relatively recent example is work I refer to broadly as “tactile telepresence for isolated patients.” Conceived of during the COVID-19 pandemic, this work is aimed at providing an isolated patient and remote visitors (e.g., loved ones) with visual interactions that are augmented by touch—a perception of being touched for the isolated patient and a perception of touching for the visitors. We do so via linear resonant actuators embedded in a headband and arm bands placed on the patient, to allow the patient to feel the sensation of the remote visitor's touch, and the vibrotactile devices in tablet computers to provide tactile feedback to the remote visitor. We presented a poster on this work at a conference in 2020. (Nafisa Mostofa, Indira Avendano, Ryan P. McMahan, and Greg Welch. Tactile Telepresence for Isolated Patients. In A. Kulik, M. Sra, K. Kim, and B.-K. Seo, editors, ICAT-EGVE 2020 - International Conference on Artificial Reality and Telexistence and Eurographics Symposium on Virtual Environments — Posters and Demos, pages 7–8. The Eurographics Association, 2020.) This work has also

resulted in two issued patents so far: U.S. Patent No. 11,287,971 (“Visual-Tactile Virtual Telepresence”) and U.S. Patent No. 11,106,357 (“Low Latency Tactile Telepresence”), both with Ryan McMahan and Gerd Bruder.

15. Another example is work I did in 2017-2022 in developing a *smart moulage*. In the context of medical simulation, *moulage* refers to a tangible pliable (e.g., silicon based) model of a wound that can be attached to a human body to simulate the shape, feel, and appearance of a wound. Our smart moulage is pliable moulage with sensors and actuators embedded inside to simulate the physical (tactile and haptic) characteristics of the wound, and passive or active features that facilitate tracking for the use of Augmented Reality to simulate the appearance of the wound. For example, the moulage can be used to sense when a trainee applies pressure to the wound, so that a physiological simulation can adjust the patient's blood pressure, and the moulage can provide vibratory feedback to simulate the pulsing sensation associated with an arterial wound. One publication of this work is in the context of combat casualty care training. (Glenn Taylor; Anthony Deschamps; Alyssa Tanaka; Denise Nicholson; Gerd Bruder; Gregory Welch; Francisco Guido-Sanz. Augmented Reality for Tactical Combat Casualty Care Training Proceedings. Augmented Cognition: Users and Contexts, pp. 227–239, Springer International Publishing, 2018, ISBN: 978-3-319-91467-1.) This work has also resulted in two issued patents so far: U.S. Patent No. 10,854,098,

(“Adaptive Visual Overlay Wound Simulation”) and U.S. Patent No. 10,803,761 (“Multisensory Wound Simulation”), both with Joseph LaViola II, Francisco Guido-Sanz, Gerd Bruder, Mindi Anderson, and Ryan Schubert.

16. Another example is my pioneering work in physical-virtual humans in general. I pioneered the use of Spatial Augmented Reality (SAR) for human patient simulators: computer graphics imagery projected on the surfaces of physical proxies for the human body. Early work focused primarily on a patient’s head, e.g., for training for stroke diagnosis. (Salam Daher; Jason Hochreiter; Nahal Norouzi; Laura Gonzalez; Gerd Bruder; Greg Welch. Physical-Virtual Agents for Healthcare Simulation Proceedings Article. Proceedings of IVA 2018, November 5-8, 2018, Sydney, NSW, Australia, ACM, 2018; Humanikins: Humanity Transfer to Physical Manikins Conference. 22nd Medicine Meets Virtual Reality (NextMed / MMVR), Los Angeles, CA, USA, 2016; Jason Hochreiter; Salam Daher; Arjun Nagendran; Laura Gonzalez; Greg Welch. Optical Touch Sensing on Non-Parametric Rear-Projection Surfaces for Interactive Physical-Virtual Experiences Journal Article. Presence: Teleoperators and Virtual Environments, vol. 25, no. 1, 2016; Jason Hochreiter; Salam Daher; Arjun Nagendran; Laura Gonzalez; Greg Welch. Touch Sensing on Non-Parametric Rear-Projection Surfaces: A Physical-Virtual Head for Hands-On Healthcare Training Journal Article. Proceedings of IEEE Virtual Reality 2015, pp. 69–74, 2015; Diego Rivera-Gutierrez; Greg Welch;

Peter Lincoln; Mary Whitton; Juan Cendan; David A. Chesnutt; Henry Fuchs; Benjamin Lok. Shader Lamps Virtual Patients: the Physical Representation of Virtual Patients Book Section. Studies in Health Technology and Informatics, Volume 173: Medicine Meets Virtual Reality 19, pp. 372–378, IOS Press, 2012.) This work culminated in what I call the physical-virtual patient bed. These are patient simulators that, among other things, incorporate temperature control of the patient proxy surfaces, touch sensing on the proxy, and tactile feedback in several locations over the patient simulator to provide the sensation of a pulse at those points on the body, e.g., the neck, groin, wrists, and ankles. This work has resulted in several publications, e.g., a 2020 article in the journal *Simulation in Healthcare*. (Salam Daher, Jason Hochreiter, Ryan Schubert, Laura Gonzalez, Juan Cendan, Mindi Anderson, Desiree A. Diaz, and Greg Welch, “The Physical-Virtual Patient Simulator: A Physical Human Form with Virtual Appearance and Behavior. *Simulation in Healthcare*,” 15(2):115–121, 2020.) It has also resulted in three issued patents so far: U.S. Patent No. 10,410,541 (“Physical-Virtual Patient Bed”) and U.S. Patent No. 9,679,500 (“Physical-Virtual Patient Bed”), both with Karen Aroian, Steven Talbert, Kelly Allred, Patricia Weinstein, Arjun Nagendran, and Remo Pillat; and U.S. Patent No. 10,380,921 (“Physical-Virtual Patient Bed System”) with Arjun Nagendran, Mary Lou Sole, and Laura Gonzalez.

17. In 2008–2009 we used Spatial Augmented Reality (SAR) to create a physical-virtual “sand table” for the US Marines. (Tyler Johnson; Herman Towles; Andrei State; Fu-Che Wu; Greg Welch; Anselmo Lastra; Henry Fuchs. A Projector-based Physical Sand Table for Tactical Planning and Review Technical Report. The University of North Carolina at Chapel Hill, Department of Computer Science Chapel Hill, NC USA, no. TR09-017, 2009.)

18. In the 2017-2019 timeframe my work included incorporating environmental tactile feedback into various Virtual Reality or Augmented Reality simulations, e.g., to simulate the feeling of someone walking nearby, the dropping/landing of an object nearby, or the vibrations of a simulated moving platform. (Kendra Richards, Nikhil Mahalanobis, Kangsoo Kim, Ryan Schubert, Myungho Lee, Salam Daher, Nahal Norouzi, Jason Hochreiter, Gerd Bruder, and Greg Welch, “Analysis of Peripheral Vision and Vibrotactile Feedback During Proximal Search Tasks with Dynamic Virtual Entities in Augmented Reality.” In Proceedings of the ACM Symposium on Spatial User Interaction (SUI), page 9, New Orleans, LA, October 19 2019. Association of Computing Machinery, ACM; Myungho Lee, Gerd Bruder, Tobias Hollerer, and Greg Welch, “Effects of Unaugmented Periphery and Vibrotactile Feedback On Proxemics with Virtual Humans In AR.” IEEE Transactions on Visualization and Computer Graphics, 24(4):1525–1534, April 2018; Myungho Lee, Gerd Bruder, and Greg Welch.

Exploring the Effect of Vibrotactile Feedback Through the Floor on Social Presence in an Immersive Virtual Environment. Proceedings of IEEE Virtual Reality 2017, pages 105–111, March 2017; Myungho Lee, Gerd Bruder, and Greg Welch, “The Virtual Pole: Exploring Human Responses to Fear of Heights in Immersive Virtual Environments,” *Journal of Virtual Reality and Broadcasting*, 14(2017)(6), 2019.)

19. In 2019–2020 I carried out work in collaboration with the University of Central Florida Police Department, supported by the Office of Naval Research, on Augmented Reality based active shooter training in a real space — the UCF Student Union. We used various proxy objects for the officer’s weapons, including a small handheld clicker the officers would aim and “click” to indicate shooting. (Gregory F Welch; Ryan Schubert; Gerd Bruder; Derrick P Stockdreher; Adam Casebolt. Augmented Reality Promises Mentally and Physically Stressful Training in Real Places Journal Article. IACLEA Campus Law Enforcement Journal, vol. 50, no. 5, pp. 47–50, 2020.)

20. My work related to embedded systems, input devices handling input and output signals, and associated event processing can be traced back to the 1980s, with my work on the “Easy Chair,” a microprocessor-based user input and control system for a motorized wheelchair for children with cerebral palsy. Codeveloper James Williams and I received an “Outstanding Senior Design

Project” award for the project in 1986. One of my core contributions to this wheelchair-related project was the development of a novel customizable touch pad to be used by children to control their wheelchairs. The touch pad combined analog and digital signals and control information associated with the pressure-sensitive hardware into a common data stream sent to a host through a common port. (James Williams and Greg Welch, “The pressure sensitive touch-pad,” Purdue University, E.E.T. 454 Project Report, April 30, 1985.) We also developed an optical version of the touch pad that multiplexed LEDs and photo sensors to detect the intersection of a point on the touch pad. The control signals and touch results were communicated to a computer through a common port. (Greg Welch, “The infrared touch-pad,” Purdue University, E.E.T. 421 Report, February 26, 1986.) We designed the Easy Chair controller and touchpad to emulate the joysticks of the original motorized wheelchair, i.e., to take over for them when in use, and to revert to the joystick control otherwise. We also developed safety controls, including speed and distance sensing and responses. For example, we developed “ultrasonic bumper” technology that slowed (or stopped) the wheelchair as it approached nearby objects. The complete functioning wheelchair, including touch pad, motor controls, safety sensors, and all user-interface aspects is described in our preliminary and final project reports. (Greg Welch and James P. Williams, “The easy chair: A microprocessor-controlled wheelchair for children with muscular

disorders,” Purdue University, E.E.T. 490/491 Senior Design Project, Preliminary Report, December 1985; Greg Welch and James P. Williams, The easy chair: A microprocessor-controlled wheelchair for children with muscular disorders, Purdue University, E.E.T. 490/491 Senior Design Project, Final Report, May 1986.)

II. MATERIALS REVIEWED AND CONSIDERED AND BASIS OF OPINION

21. In connection with my work on this matter, I have reviewed the ’067 patent, its prosecution history, and the prior art and other documents and materials listed in the table below. Each of these materials is a type of document that experts in my field would have reasonably relied upon when forming their opinions and to which they would have had access, either through the applicable patent office and/or well-known libraries, conferences, publications, organizations, and websites in the field.

Exhibit	Description
1001	U.S. Patent No. 10,665,067
1002	Prosecution History of U.S. Patent No. 10,665,067
1005	Plaintiff’s Preliminary Infringement Contentions, <i>Immersion Corp. v. Valve Corp.</i> , 2:23-cv-00712 (W.D. Wash.) (served Oct. 20, 2023)
1006	Exhibit F to Plaintiff’s Preliminary Infringement Contentions, <i>Immersion Corp. v. Valve Corp.</i> , 2:23-cv-00712 (W.D. Wash.) (served Oct. 20, 2023)
1008	U.S. Patent Appl. Publ. No. 2018/0144549 (“Gonzales”)
1009	U.S. Patent Appl. Publ. No. 2016/0274662 (“Rimon”)
1010	U.S. Patent Appl. Publ. No. 2017/0354864 (“Rogers”)

1011	U.S. Patent Appl. Publ. No. 2017/0108930 (“Banerjee”)
1012	U.S. Patent Appl. Publ. No. 2012/0045742 (“Meglan”)
1013	Ronald T. Azuma, “A survey of augmented reality,” <i>Presence: Teleoperators and Virtual Environments</i> , vol. 6, no.4, pp.355-385, August, 1997 (“Azuma”).
1014	Carmigniani <i>et al.</i> , “Augmented reality technologies, systems and applications,” <i>Multimedia Tools and Applications</i> (2011) 51:341–377, (“Carmigniani”).
1015	Araujo <i>et al.</i> , “An haptic-based immersive environment for shape analysis and modelling,” <i>Journal of Real-Time Image Processing</i> (2010) 5:73–90 (“Araujo”)
1016	U.S. Patent No. 7,812,815 (“Banerjee-815”)
1017	U.S. Patent No. 6,417,638 (“Guy”)
1018	U.S. Patent No. 7,411,576 (“Massie-576”)
1019	U.S. Patent Appl. Publ. No. 2010/0291505 (“Rawley”)
1020	Ronald T. Azuma, “A survey of augmented reality,” <i>Presence: Teleoperators and Virtual Environments</i> , vol. 6, no.4, pp.355-385, August, 1997 (“Azuma-Stamped-Copy”)
1021	U.S. Patent No. 9,563,266 (“Banerjee-266”)
1022	U.S. Patent Appl. Publ. No. 2002/0097223 (“Rosenburg”)
1023	U.S. Patent No. 5,587,937 (“Massie-937”)
1024	U.S. Patent No. 11,127,306 (“Goel”)
1025	U.S. Patent No. 10,172,676 (“Ecabert”)
1026	U.S. Patent Appl. Publ. No. 2018/0335841 (“Rubin”)
1027	U.S. Patent No. 9,881,520 (“Ullrich-520”)
1028	U.S. Patent No. 10,146,335 (“Balan”)
1032	U.S. Patent Appl. Publ. No. 2009/0263775 (“Ullrich-775”)
1033	U.S. Patent Appl. Publ. No. 2019/0179426 (“Ojala”)
1034	U.S. Patent No. 10,701,318 (“Valli”)

1035	U.S. Patent Appl. Publ. No. 2018/0050268 (“Jones”)
1036	U.S. Patent No. 10,319,109 (“Murrish”)
1037	U.S. Patent No. 10,803,761 (“Welch”)

22. My opinions in this Declaration are based on my review of these documents, as well as upon my education, training, research, knowledge, and experience. When developing the opinions set forth in this Declaration, I assumed the perspective of a person having ordinary skill in the art (“POSA”), as of the filing date of the ’067 patent, as described in Section IV below.

III. MY UNDERSTANDING OF PATENT LAW

23. In developing my opinions, I discussed various relevant legal principles with Petitioner’s attorneys. Though I do not purport to have prior knowledge of such principles, I understood them when they were explained to me and have relied upon such legal principles, as explained to me, in the course of forming the opinions set forth in this declaration. My understanding in this respect is as follows:

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

25. I understand that, in this proceeding, Petitioner has the burden of proving that the challenged claims of the ’067 patent are unpatentable by a

preponderance of the evidence. I understand that “preponderance of the evidence” means that a fact or conclusion is more likely true than not true.

26. I understand that, in IPR proceedings, claim terms in a patent are given their ordinary and customary meaning as understood by a person of ordinary skill in the art (“POSA”) in the context of the entire patent and the prosecution history pertaining to the patent. If the specification provides a special definition for a claim term that differs from the meaning the term would otherwise possess, the specification’s special definition controls. If a claim element is expressed as a “means” for performing a specified function, I understand that it covers the corresponding structure described in the specification and equivalents of the described structure. I have applied these standards in preparing the opinions in this declaration.

27. I understand that determining whether a particular patent or printed publication constitutes prior art to a challenged patent claim can require determining the effective filing date (also known as the priority date) to which the challenged claim is entitled. I understand that for a patent claim to be entitled to the benefit of the filing date of an earlier application to which the patent claims priority, the earlier application must have described the claimed invention in sufficient detail to convey with reasonable clarity to the POSA that the inventor had possession of the claimed invention as of the earlier application’s filing date. I

understand that a disclosure that merely renders the claimed invention obvious is not sufficient written description for the claim to be entitled to the benefit of the filing date of the application containing that disclosure.

28. I understand that for an invention claimed in a patent to be patentable, it must be, among other things, new (novel—i.e., not anticipated) and not obvious from the prior art. My understanding of these two legal standards is set forth below.

A. Anticipation

29. I understand that, for a patent claim to be “anticipated” by the prior art (and therefore not novel), each and every limitation of the claim must be found, expressly or inherently, in a single prior-art reference. I understand that a claim limitation is disclosed for the purpose of anticipation if a POSA would have understood the reference to disclose the limitation based on inferences that a POSA would reasonably be expected to draw from the explicit teachings in the reference when read in light of the POSA’s knowledge and experience.

30. I understand that a claim limitation is inherent in a prior-art reference if that limitation is necessarily present when practicing the teachings of the reference, regardless of whether a person of ordinary skill recognized the presence of that limitation in the prior art.

B. Obviousness

31. I understand that a patent claim may be unpatentable if it would have been obvious in view of a single prior-art reference or a combination of prior-art references.

32. I understand that a patent claim is obvious if the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the relevant field at the time the invention was made. Specifically, I understand that the obviousness question involves a consideration of: the scope and content of the prior art; the differences between the prior art and the claims at issue; the knowledge of a POSA; and, if present, any “secondary considerations” of non-obviousness. At this stage I am unaware of the patent owner identifying any alleged secondary considerations of non-obviousness with respect to the '067 patent, but if any secondary considerations are later presented, I would be happy to evaluate and comment thereon if asked to do so.

33. I understand that in order for a claimed invention to be considered obvious, a POSA must have had a reason for combining teachings from multiple prior-art references (or for altering a single prior-art reference, in the case of obviousness in view of a single reference) in the fashion proposed.

34. I have also been informed that in considering whether a combination of elements recited in a patent claim would have been obvious, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior-art references, the effects of demands known to the design community or present in the marketplace, and/or the background knowledge possessed by a POSA. I have been informed that other principles may be relied upon in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a POSA can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a POSA would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond a POSA's skill;

- An explicit or implicit reason to modify a prior-art reference or to combine two prior-art references to arrive at the claimed invention may demonstrate obviousness, and this reason may come from a prior-art reference or from the knowledge or common sense of a POSA;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- In determining whether the subject matter of a patent claim would have been obvious, neither the particular motivation nor the avowed purpose of the named inventor controls;
- One consideration supporting obviousness of a patent claim is if there existed at the time of invention a known problem for which there was an obvious solution encompassed by the claim;
- Any need or problem known in the field of endeavor at the time of invention can provide a reason for combining the elements in the manner claimed;
- Common sense teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a POSA will be able to fit the teachings of multiple patents together like pieces of a puzzle;

- A POSA is a person of ordinary creativity, and is not an automaton;
- A patent claim may be obvious if the claimed combination of elements was “obvious to try,” particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a POSA would have had good reason to pursue the known options within his or her technical grasp; and
- One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

35. I understand that obviousness requires a POSA to have a reasonable expectation of success in combining multiple prior-art references. I understand that a reasonable expectation of success refers to the likelihood of success in combining references to meet the limitations of the claimed invention. I understand that in evaluating a combination, a predictable result means not only that the prior art elements are capable of being physically combined, but also that the combination would have worked for its intended purpose.

IV. PERSON OF ORDINARY SKILL IN THE ART (“POSA”)

36. I have been informed and understand that for purposes of assessing whether prior-art references disclose every element of a patent claim (thus “anticipating” the claim) and/or would have rendered the claim obvious, the patent

and the prior-art references must be assessed from the perspective of a person having ordinary skill in the art (“POSA”) to which the patent is related, based on the understanding of that person at the time of the patent claim’s priority date. I have been informed and understand that a POSA is presumed to be aware of all pertinent prior art and the conventional wisdom in the art, and is a person of ordinary creativity. I have applied this standard throughout my declaration.

37. Based on my review of the ’067 patent, the relevant general fields for the purposes of the ’067 patent are hardware and software designs for integrating haptics in virtual reality and augmented reality systems. I have been asked to provide my opinions as to the state of the art in this field on or before June 15, 2018. I use this timeframe because the face of the ’067 patent indicates a filing date of June 15, 2018 and I have been informed by Valve’s counsel that the ’067 patent does not claim an earlier priority date. Whenever I offer an opinion in this declaration about the knowledge of a POSA, the manner in which a POSA would have understood the claims of the ’067 patent or its description, the manner in which a POSA would have understood the prior art, or what a POSA would have been led to do based on the prior art, I am referencing the timeframe on or before June 15, 2018, even if I do not say so specifically in each case.

38. I was asked to provide an opinion as to the level of ordinary skill in the art pertinent to the subject matter of the ’067 patent on or before June 15, 2018.

I understand that factors to be considered in evaluating the level of ordinary skill in the art include the types of problems encountered in the art, the prior art solutions to those problems, the rapidity with which innovations in the field are made, the sophistication of the technology, and the educational level and professional capabilities of workers in the field.

39. In my opinion, the person of ordinary skill in the art (POSA) on or before the '067 patent's filing date of June 15, 2018 would have had a bachelor's degree in electrical engineering, computer science, or a related field, plus at least two years of industry experience or graduate-level academic experience with human-computer interaction. More education could substitute for experience, and *vice versa*. This person would have been capable of understanding and applying the teachings of the '067 patent and the prior-art references discussed in this Declaration.

40. I have worked with many people who fit the characteristics of the POSA, and I am familiar with their level of skill in and around June 2018. When developing the opinions set forth in this declaration, I did so from the perspective of a POSA, as set forth above, as of the June 2018 timeframe. Even though I had greater than the ordinary level of skill in the art as of 2018 (since I earned my Ph.D. in 1997 and had about 20 years of post-Ph.D. experience by 2018), I am able to apply the POSA standard in this Declaration because I have long been familiar

with, and have worked extensively with (including before June 2018) people having an ordinary level of skill and experience in the field of the '067 patent, including many of the students I have advised or co-advised.

V. THE '067 PATENT

41. The '067 patent is directed to systems and methods for “integrating haptics” into “augmented reality” (AR) applications. EX1001, 1:9. In the “Background” section, the '067 patent acknowledged that then-known virtual reality (VR) applications integrated haptics, typically by using a “dedicated controller to allow the user to feel a touch sensation of the virtual object.” EX1001, 1:15-16. As an example, the '067 patent describes the common gaming scenario in which “a VR user may experience a gun shooting in his hand in the VR application and may simultaneously feel a haptic effect simulating that shooting through the dedicated controller.” EX1001, 1:16-19.

42. In contrast to these known VR systems, the '067 patent alleged that “[i]n AR space, it is difficult to provide a haptic effect to the user,” and thus techniques “for integrating haptics overlay in augmented reality are needed.” EX1001, 1:19-22. The '067 patent thus distinguishes VR applications and describes “systems and methods for integrating haptics overlay in augmented reality.” 1:26-28. As demonstrated by the prior art discussed in further detail below, conventional AR (also called mixed reality) systems integrated haptics

using the same well-known techniques and conventional AR displays and haptic devices disclosed in the '067 patent.

A. Virtual and Augmented Reality

43. A POSA would have understood the terms virtual reality (VR) and augmented reality (AR) to have different meaning as the '067 patent acknowledges in the background. EX1001, 1:13-22. VR systems display only a virtual environment, whereas AR systems display aspects of both a virtual environment and the actual physical environment as perceived by the user, as discussed in connection with the exemplary references briefly discussed below that corroborate this understood distinction between VR and AR.

- EX1013 (“Azuma”) is an oft-cited (16,800 citations) survey paper titled “A Survey of Augmented Reality,” published in *Presence: Teleoperators and Virtual Environments*” in 1997¹ by well-known researcher Ronald Azuma, characterizing the distinction as such: “*Augmented Reality* (AR) is a variation of *Virtual Environments* (VE), or virtual reality as it is more commonly called. VE technologies completely immerse a user inside a synthetic environment. While immersed, the user cannot see the real world around him. In contrast, AR allows the user to see the real world, with

¹ EX1020 is a stamped copy of EX1013 from the library at University of Wisconsin, Madison showing the cover information and the library stamp showing that this publication was available by at least August 14, 1997. EX1020, 4.

virtual objects superimposed upon or composited with the real world.

Therefore, AR supplements reality, rather than completely replacing it.”

(emphasis original). EX1013, 355-356. Azuma further characterizes “AR as

any system that has the following three characteristics: 1) Combines real

and virtual; 2) Is interactive in real time; 3) Is registered in three

dimensions.” EX1013, 356. AR systems combine real and virtual using two

primary techniques: “optical see-through” illustrated in Azuma’s Figure 11

(below left) and “video see-through” illustrated in Azuma’s Figure 13

(below right). I discuss these display techniques in further detail in §V.A.2

below in the discussion of conventional AR systems.

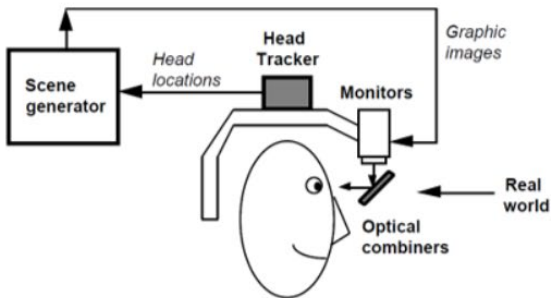


Figure 11: Optical see-through HMD conceptual diagram

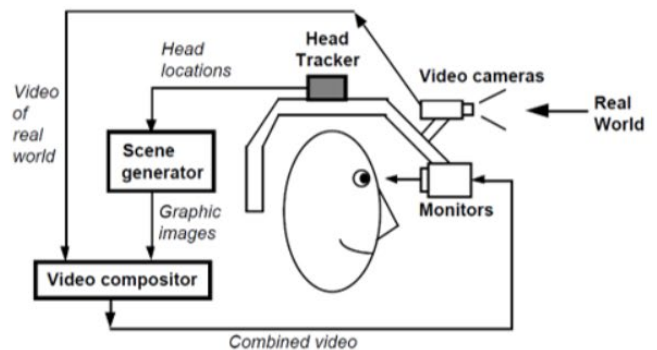


Figure 13: Video see-through HMD conceptual diagram

- EX1014 is a survey paper titled “Augmented reality technologies, systems and applications,” published in Multimedia and Tools Applications (2011) 51:341–377 and published online in 2010, which similarly defines “Augmented Reality (AR) as a real-time direct or indirect view of a physical real-world environment that has been enhanced / *augmented* by

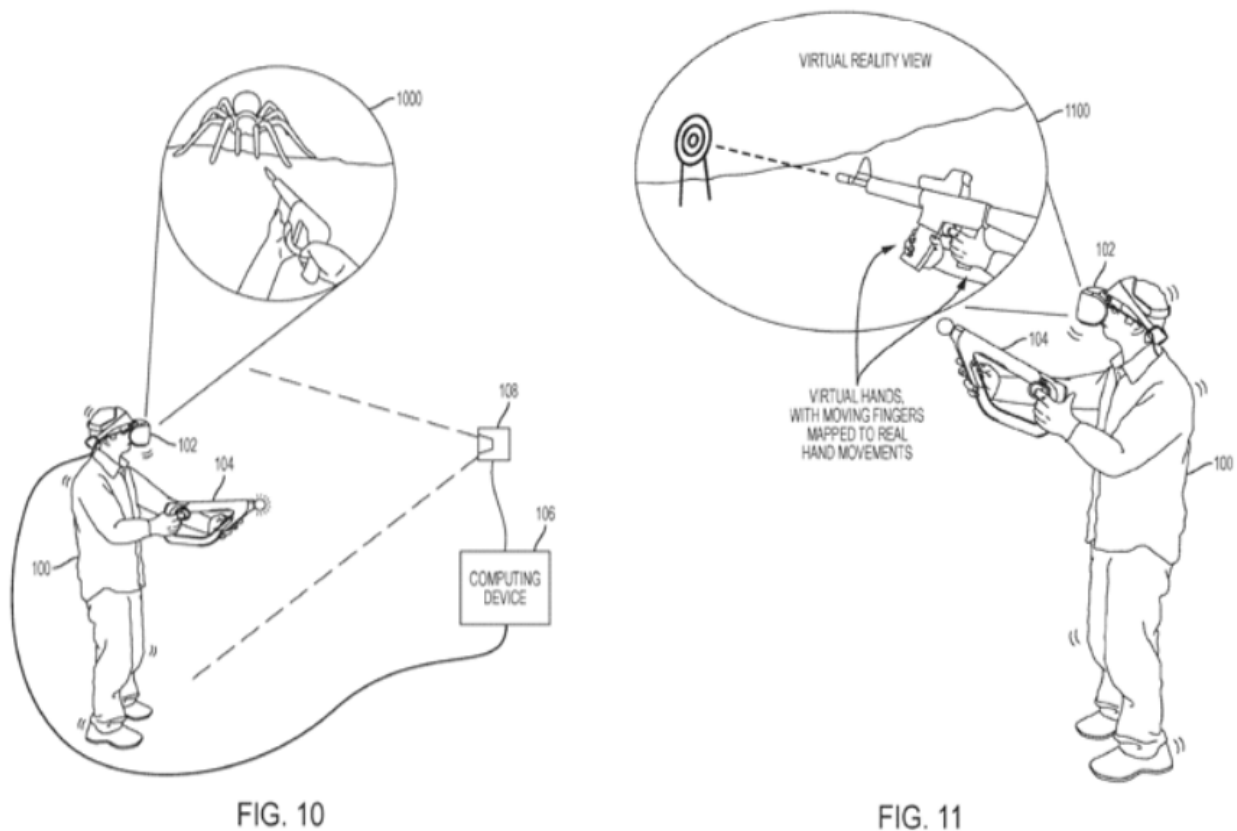
adding virtual computer-generated information to it.” EX1014, 342. The “direct” view of the physical real-world is achieved using “optical see-through” displays, whereas the “indirect” view of the real-world is achieved using “video-see-through” displays. EX1014, 346-347.

- EX1008 likewise makes this same distinction: “AR and virtual reality (“VR”) are not the same thing. In VR, a user is wearing a VR headset which does not allow the user to see the outside world...In other words, the purpose of VR is to immerse the user in a VR world so that they forget about the real-world entirely.” EX1008, [0044].
- EX1010 discloses that a head-mounted display (HMD) 102 used for virtual reality gameplay can include video cameras to capture the physical environment that “can be presented to the user...with a ‘video see-through’ ability.” EX1010, [0063]. The captured video of the physical environment “can be augmented with virtual elements to provide an augmented reality experience.” EX1010, [0063].

1. Virtual Reality Systems

44. As the goal of VR is immersion, VR systems commonly utilize a VR headset (e.g., a head-mounted display (HMD)) that occludes the physical environment such that the user sees only the computer-generated objects in the virtual environment. EX1008, [0044]-[0046]. For example, FIGS. 10 and 11 of

EX1010 (“Rogers”) illustrate a VR system in which a user wears a HMD 102 and holds an interface object 104 in his/her hands. In the virtual reality view 1000, 1100, the user sees only virtual objects generated by the VR application—e.g., a virtual spider (FIG. 10), virtual target (FIG. 11) and “virtual hands” holding a “virtual weapon/object” (FIGS. 10 and 11). EX1010 (Rogers), [0096].



45. The user sees virtual hands and a virtual weapon that move in correspondence with the user’s actual hands holding the physical interface object 104 by virtue of a tracking system, but the virtual hands and virtual weapon are computer-generated (i.e., computer-generated 3D models of hands and the desired virtual weapon) while the user’s actual hands and interface object 104 are not

visible. EX1010 (Rogers), [0107]-[0109]. That is, if the virtual objects were not rendered on the display, the user would see nothing because the physical world is occluded. VR systems may also employ conventional displays that are not fully immersive, but the principal is the same—i.e., the VR display itself consists of the computed-generated virtual environment, though the user may incidentally see the surrounding physical environment that is not part of the display.

2. Augmented Reality Systems

46. As discussed above, AR differs from VR in that instead of presenting a purely virtual environment to the user as in VR, AR systems combine aspects of both a virtual environment and the physical environment. The two basic techniques for visually combining virtual and real environments are: (1) optical techniques in which a user sees the real environment directly; and (2) video techniques in which the user sees the real environment indirectly via video capture of the real environment.

a. Optical AR Displays

47. Optical techniques for combining aspects of a virtual and real environment are most commonly achieved using “optical see-through” (OST) in which a partially transmissive, partially reflective optical combiner is placed between the user’s eyes and the real environment so that the user simultaneously sees an unmediated view of the real environment through the optical combiner, and

superimposed imagery of virtual content output by a monitor or screen reflected by the optical combiner. *See, e.g.,* EX1013, 361-362, Figure 11; EX1011, [0029], [0035], [0052]-[0054], FIGS. 1, 3, 19-21; EX1012, [0129]-[0133], FIG. 9; EX1015, 77-80; EX1028, 3:1-6:44, FIGS. 1-2. Figure 11 of EX1013 reproduced below illustrates this optical see-through concept in the context of a head-mounted display (HMD).

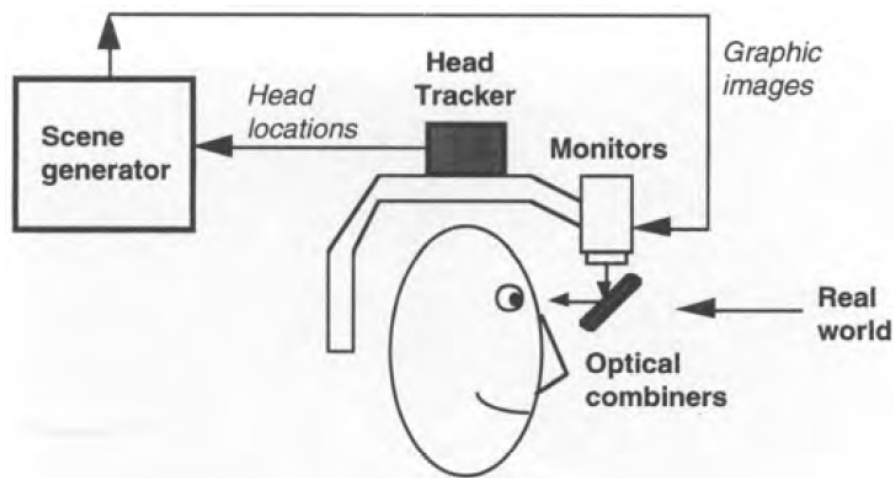


Figure 11. Optical see-through HMD conceptual diagram.

48. Specifically, the user sees the real world through the optical combiner because it is partially transmissive. EX1013, 361-362. Virtual content is generated by a computer in essentially the same manner as in VR applications. This computer-generated virtual environment is provided to head-mounted monitors as “graphic images” (i.e., 2D projections of the 3D models of the virtual objects in the virtual environment from the current perspective of the user tracked via the head tracker). The virtual environment output by the monitors is reflected by the optical

combiner so that the user sees the combined virtual and real environment. EX1013, 361-362. Unlike in VR, if the scene generator did not generate any virtual object, the user would still see the real world without the virtual augmentation. Figure 1 of EX1013 illustrates an example of an AR view in which a user looking at a real table also sees virtual chairs and a virtual lamp via the AR display. EX1013, 356.

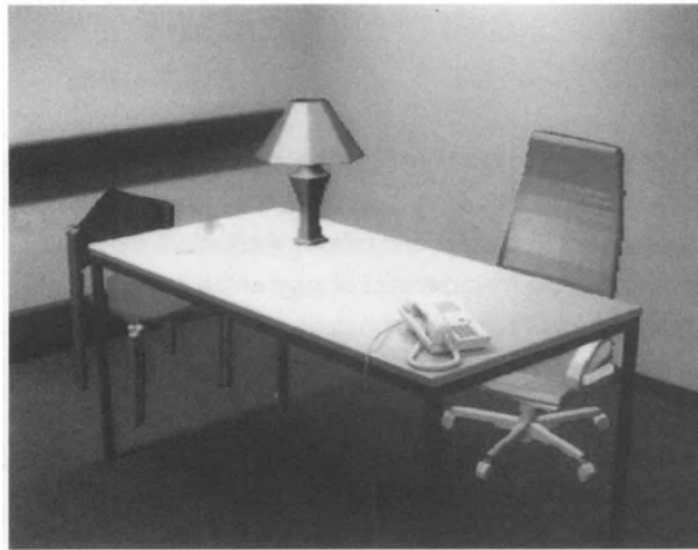


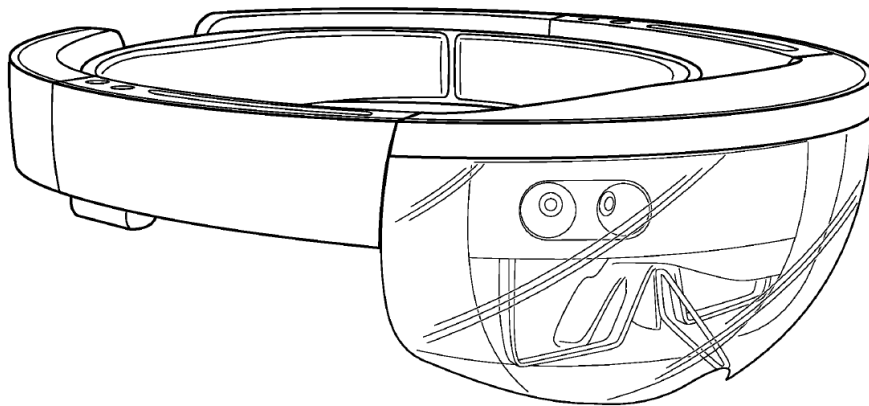
Figure 1. Real desk with virtual lamp and two virtual chairs. (Courtesy ECRC.)

49. Figure 12 from EX1013 illustrates examples of actual optical see-through HMDs in the 1997 timeframe. EX1013, 362.



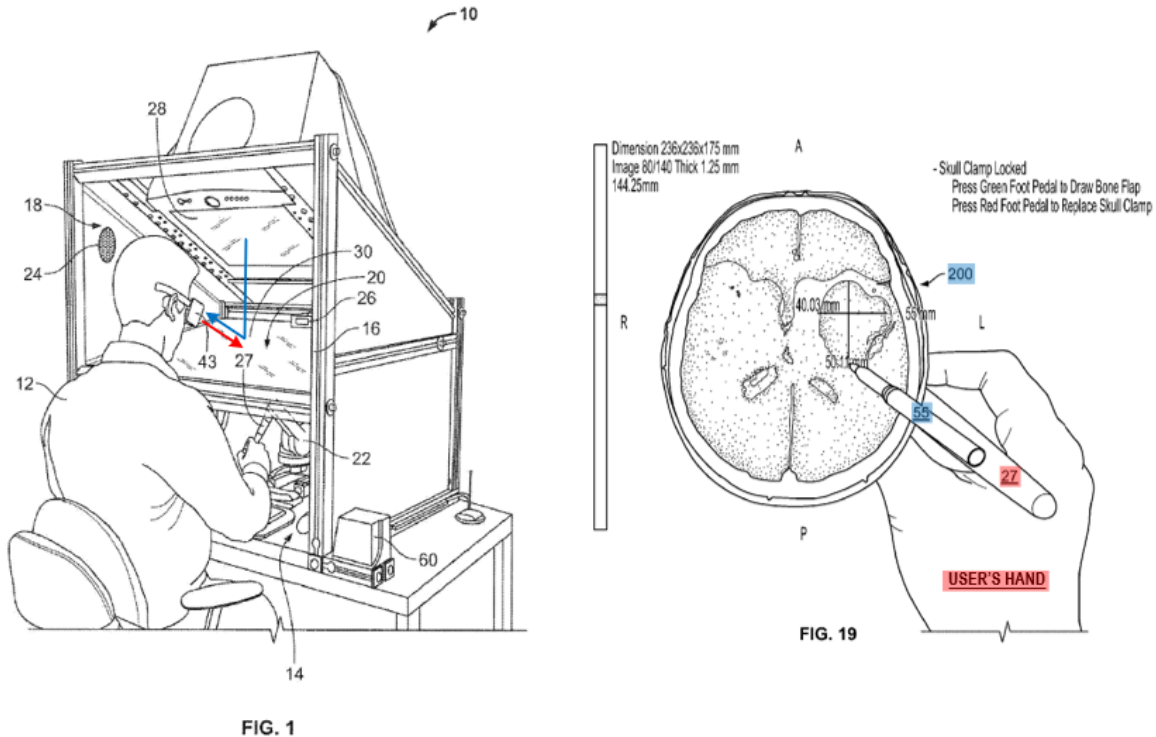
Figure 12. Two optical see-through HMDs, made by Hughes Electronics.

50. Well known examples of optical see-through displays include AR headsets such as Microsoft Hololens (below²) and smart glasses such as Google Glass. Head-up displays (HUDs) such as those commonly used in aircrafts and in passenger vehicles similarly use optical see-through technology. EX1013, 361-362; *see also* EX1008, [0046] (disclosing the user of an OST AR headset).



² FIG. 2 of EX1028 showing the “Microsoft Hololens.” EX1028, 2:25-26, 5:16-34.

51. EX1011 (“Banerjee”) discloses another example of a system that utilizes optical see-through to implement an AR system wherein an optical combiner is implemented as a partially transparent or half-silvered mirror. As shown in FIG. 1 of Banerjee (below left), a user simultaneously sees the physical environment through partially transparent mirror 30 (**red** arrow) and a virtual surgery simulation output from screen 28 and reflected by the mirror (**blue** arrow). FIG. 19 of Banerjee (below right) illustrates a view of what the user sees where a virtual surgical marker 55 (i.e., a marker of the type used to draw on medical images and on the patient themselves) is selected to annotate on simulated radiology scan 200 the location of the bone flap to be removed in a craniotomy procedure. EX1011 (Banerjee), [0029], [0035], [0052]-[0053]. Real objects viewed by the user are emphasized in **red** and virtual objects seen by the user are emphasized in **blue**.



52. Thus, optical see-through displays were both implemented as shown in Banerjee (see also EX1012, [0129]-[132], FIG. 9; EX1015, 78, 80, FIGS. 4, 5, 7 and 8) and integrated into HMDs as discussed above. Banerjee in fact says that it was understood that the views displayed by the system illustrated in FIG. 1 could be implemented using Microsoft Hololens, demonstrating that a POSA would have understood that these two implementations were interchangeable and either could be used to implement OST. EX1011 (Banerjee), [0072].

53. Optical AR displays were also sometimes implemented by projecting a virtual environment directly onto the real environment using some form of a digital projector. In such AR projection displays, the real world effectively

provides a contoured projection screen on which a virtual environment is displayed. EX1012, [0142]-[0144], FIG. 11.

b. Video AR Displays

54. AR video techniques are typically implemented using video pass-through displays in which a user views the physical world indirectly via video capture of the real world (very much like what the user sees when using a smartphone) and sees a virtual environment as an overlay on the real-time video feed of the real world. Figure 13 of EX1013 reproduced below illustrates this video see-through (VST) concept in the context of an HMD.

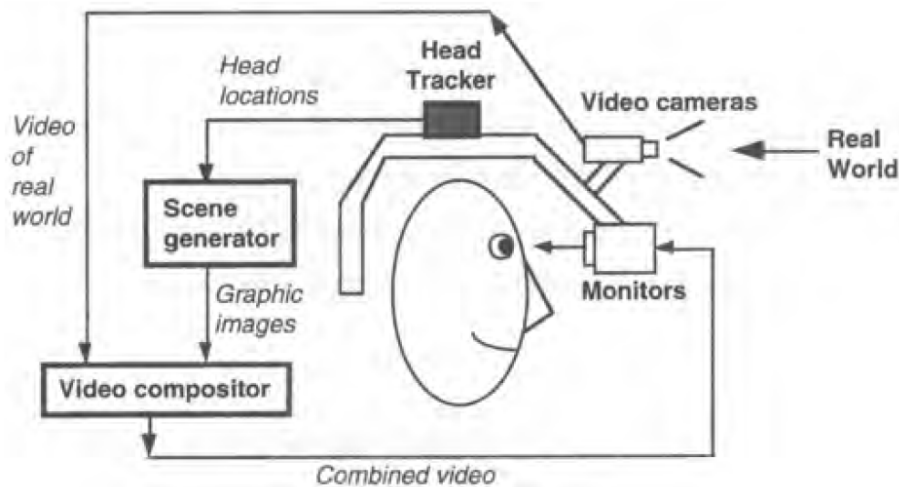


Figure 13. Video see-through HMD conceptual diagram.

55. As illustrated, video cameras on the HMD capture video of the real world. The virtual environment is then overlaid on the real-time video and displayed to the user via the monitors. EX1013, 362-363. More specifically, graphic images of the virtual scene are overlaid on frames of the video feed

captured of the real world to produce a composite video of the combined virtual and real environment. EX1013, 362-363. Figure 14 of EX1013 reproduced below illustrates an actual video see-through HMD circa 1997 with a pair of video cameras to provide stereoscopic video of the real world. I personally used this HMD (and several others like it) in the 1990s when I was at the University of North Carolina at Chapel Hill.

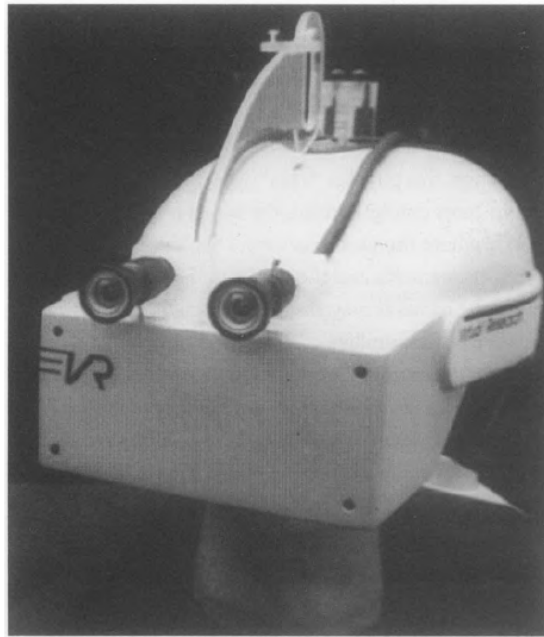


Figure 14. An actual video see-through HMD. (Courtesy Jannick Rolland, Frank Biocca, and UNC Chapel Hill Dept. of Computer Science. Photo by Alex Tremi.)

56. Like AR optical see-through displays, video see-through systems without HMDs were also known and often used, as illustrated in Figure 15 of EX1013. As shown, the concept is the same but the display components are not mounted to the user's moving head as in the HMD implementation, they are instead fixed in the world. EX1013, 362-363.

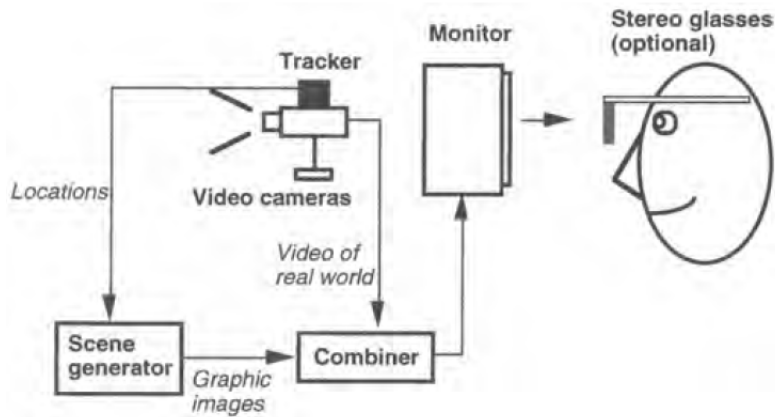
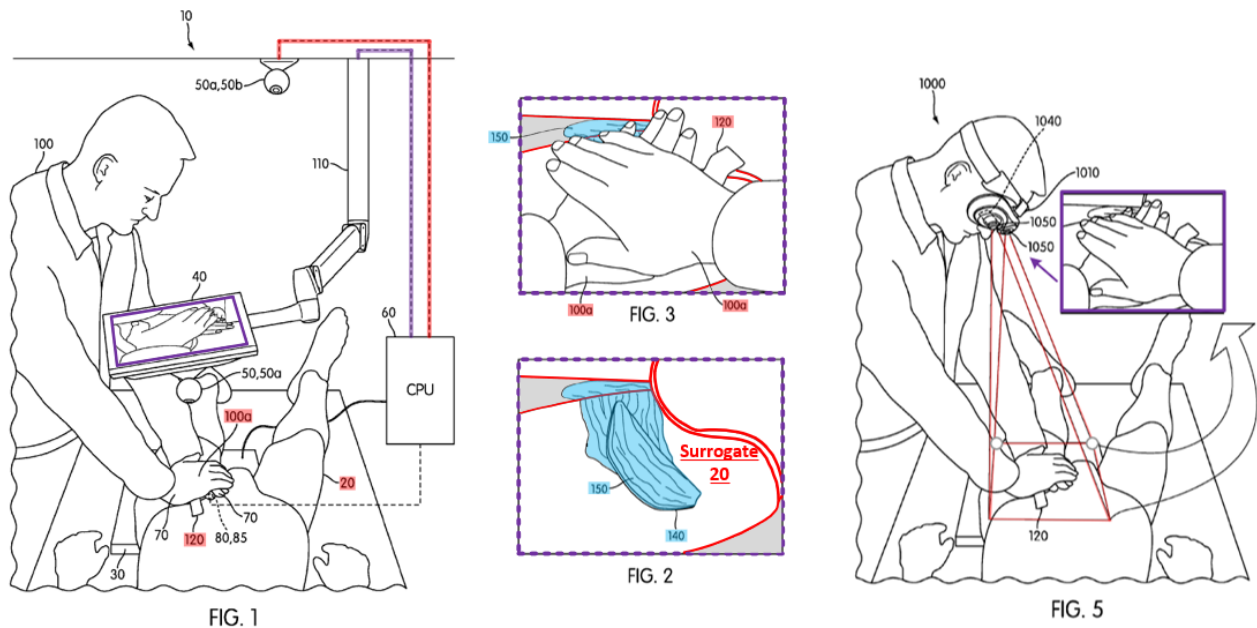


Figure 15. *Monitor-based AR conceptual diagram.*

57. EX1012 (“Meglan”) discloses video see-through AR systems implemented using a monitored-based approach (see FIG. 1 of Meglan reproduced below at left) similar to the system illustrated in Figure 15 of EX1013 above and using an HMD approach (see FIG. 5 of Meglan reproduced below at right) similar to the HMD system illustrated in Figure 13 of EX1013 above. Specifically, Meglan discloses hemorrhage control simulators that allow trainees to practice controlling blood flow of a trauma victim by overlaying a virtual trauma on the real-time video of a trainee interacting with a mannequin. Meglan (EX1012), [0082].



58. As shown with **red** (real) and **blue** (virtual) annotations in Meglan's figures above, a processor 60 generates composite video of an AR environment of a trauma victim by combining a virtual wound 140 and blood flow 150 with the video feed of the real world captured by a video camera system (video camera system 50 in FIG. 1 and HMD-integrated camera system 1050 in FIG. 5). The physical environment includes surrogate 20 (i.e., a mannequin) on which a virtual trauma is simulated, the user hands (when present) and other real-world objects the trainee may use to control the hemorrhage. EX1012, [0066], [0070]-[0072], [0082]-[0083], [0094]. For example, FIG. 2 (above at center bottom) illustrates a snapshot of the composite video showing virtual wound 140 and blood flow 150 overlaid on the video feed of the real-world surrogate 20 before the trainee begins treatment and FIG. 3 (above at center top) illustrates a snapshot of the composite

video after the trainee has begun interacting with surrogate 20 to control the hemorrhage. EX1012, [0049], [0070], [0082].

B. Proxy Objects

59. In the field of VR and AR, the term proxy object (also referred to as a surrogate) is used to refer to a real-world object having a virtual counterpart as corroborated by the example prior-art references briefly discussed below:

- EX1033 describes mixed-reality applications in which a “stick-shaped real-world object” is used as a “proxy object” for different virtual counterparts ([0046]), e.g., a torch, sword, baseball bat, pen, paint brush, etc. EX1033, [0024], [0030], [0046]-[0047], [0069].
- EX1036 describes using “physical objects as proxy objects representing virtual objects” in a VR robotics system. EX1036, 2:28-48, 7:20-23. In one example, a “Frisbee” is used as a proxy object for “a virtual reality steering wheel” in a racing game. EX1036, 7:40-8:13.
- EX1032 describes AR surgical simulation and training systems in which “a simple rod or other structure having the basic physical shape of a surgical tool” is used as a “proxy” for a specific virtual surgical instrument counterpart in the surgical simulation ([0072]). EX1032, [0027], [0045]-[0047], [0072], [0081].

- EX1011 (Banerjee) describes AR and VR systems for simulating surgical procedure in which a real-world “haptic stylus” is used as a “proxy” for different virtual surgical instrument counterparts ([0029]-[0030]) used in performing a simulated surgical procedure. EX1011, [0035], [0042]-[0044], [0053]-[0070].
- EX1012 (Meglan) describes a hemorrhage control simulator using a real world mannequin/substrate as a “physical surrogate” ([0066]) for a virtual trauma victim counterpart on which a trainee practices treating a virtual wound. EX1012, [0059], [0061], [0122], [0125] (describing different objects used as a “surrogate for another object”).
- EX1034 uses the terms “proxy” and “surrogate” interchangeably for a physical participant and its virtual electronic representative counterpart in an AR telepresence system. EX1034, 7:54-60.

60. In VR and AR, a proxy object’s virtual counterpart typically responds to the user’s interaction with the proxy object. For example, in the system in EX1010 discussed above in §V.A.1 (“Virtual Reality Systems”) where the user holds and manipulates an interface object to control a virtual weapon in a video game. EX1010, [0107]-[0109]. *See also* Banerjee (EX1011), [0029]-[0030], [0042]-[0044], [0053]-[0068] (describing manipulating virtual surgical tools using via a physical stylus held by the user as a proxy for the virtual tool); Meglan

(EX1012), [0059]-[0072], [0082], [0107], [0118], [0122] (simulating virtual wound based on trainee's interaction with surrogate); EX1033, [0024], [0030], [0046]-[0055], [0069] (disclosing tracking a proxy object held by the user to control a virtual torch, sword, paint brush, etc. in the virtual environment); EX1036, 7:40-8:13 (describing controlling a virtual steering wheel using a real-world Frisbee).

61. As I discuss in further detail in the “Described Embodiments” section below (§V.C), the '067 patent's embodiments augment the appearance of a real-world proxy object (which “may take the form of any object,” 5:34-37) by displaying a selected color/texture visually superimposed on the proxy object via the AR display. EX1001, 2:49-52 (“the appearance of the proxy object is modified through the AR display to show the proxy object made of the selected material”), 3:1-4 (the user will see “modified image of the proxy object through the AR display”), 5:60-65 (“So, the user 206 will be able to view the proxy object with the chosen texture through the wearable AR device 204. For example, if the user 206 chooses a red leather, then the user 206 will see the proxy object 202 made of that same red leather through the wearable AR device 204”), 8:16-24.

62. The AR systems disclosed in Banerjee and Meglan that I discussed above in §V.A.2 (“Augmented Reality Systems”) as examples of OST and VST AR systems, respectively, likewise augment the appearance of the real-world

proxy objects via their respective AR displays. Banerjee (EX1011), [0029], [0034]-[0035], [0042]-[0044], [0053]-[0068] (superimposing a virtual surgical tool to make a physical haptic device's stylus look like the particular surgical instrument); Meglan (EX1012), [0059]-[0072], [0082], [0107], [0118], [0122] (overlaying a simulated wound on video of a physical mannequin to make it appear to have suffered a trauma).

C. Described Embodiments

63. As I discussed above in §V, the '067 patent discloses that haptics are typically integrated in VR applications using a “dedicated controller” and provides the example where “a VR user may experience a gun shooting in his hand in the VR application and may simultaneously feel a haptic effect simulating that shooting through the dedicated controller.” EX1001, 1:14-19. The '067 patent alleges that “[i]n AR space, it is difficult to provide a haptic effect to the user,” and thus techniques “for integrating haptics overlay in augmented reality are needed.” EX1001, 1:14-22. A POSA would have understood from this “Background” discussion that the disclosed systems are AR and not VR systems and the disclosed embodiments reinforce this understanding.

64. To address the alleged need of integrating haptics in AR, the patent discloses a system that “allow[s] a user to see and feel a texture on a real world

object using a haptics overlay on that object.” 2:31-33. Figure 2 (below) illustrates a system “for integrating haptics overlay in augmented reality” (5:23-24):

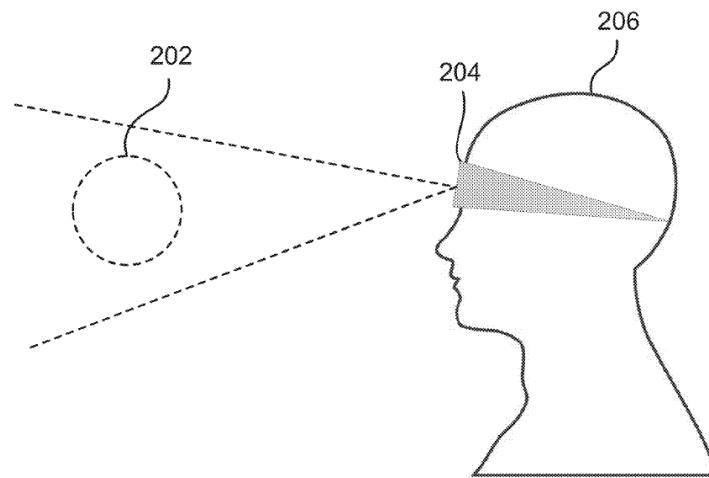


Figure 2

65. The '067 patent states that Figure 2 shows “a user 206 is wearing a wearable AR device 204 and interacting with a proxy object 202” and further states that “[t]hough this embodiment shows the user wearing a wearable AR device 204, any type of AR display system may be used.” EX1001, 5:24-28. The '067 patent discloses that “proxy object 202 may take the form of any object, including, but not limited to, a shoe, a bag, an article of clothing, an electronic device, a display, or an interface object.” 5:34-36.

66. The '067 patent discloses that user 206 can choose a texture from a library of textures using, for example, an “input capture device” such as “touchscreen, a keyboard, a mouse, a joystick,” etc. (5:51-53) and “an augmented reality visual effect will modify the appearance of the proxy object through the wearable AR device” so that the “user 206 will be able to view the proxy object

with the chosen texture through the wearable AR device 204.” EX1001, 5:45-62.

The '067 patent states that, “[f]or example, if the user 206 chooses a red leather, then the user 206 will see the proxy object 202 made of that same red leather through the wearable AR device 204.” EX1001, 5:62-65.

67. The '067 patent further states that a “haptic effect associated with the selected texture” is output by “haptic output device(s) 118 contained in proxy object 202” (5:66-6:5) so that the “AR visual effect may be felt and seen, respectively” (6:8-9). As seen in Figure 2 above, proxy object 202 is illustrated as a circle in dashed lines with no illustrated haptic device. The '067 patent does not explain how haptic output devices are “contained in proxy object 202,” nor does the '067 patent describe specific examples where haptic devices are contained in a proxy object (beyond merely using those words) or the means by which that would be achieved.

68. In the Figure 3 embodiment (below), the '067 patent says that “a user is wearing a wearable AR device 306 and a wearable peripheral device 304 and interacting with a proxy object 302.” EX1001, 6:15-29. The '067 patent states that “[w]earable peripheral device 304 may comprise a glove that covers the user’s whole hand, a glove that covers only some of the user’s hand and fingers, e.g., only the user’s thumb and index finger.” EX1001, 6:21-24.

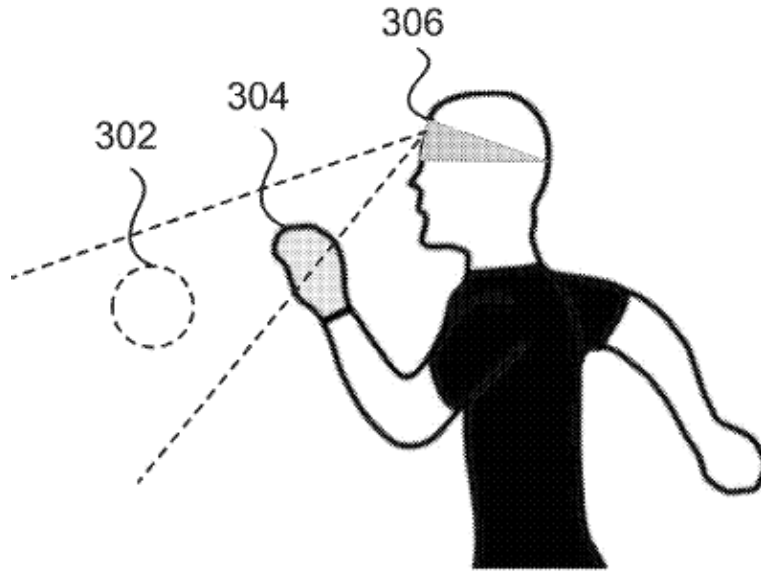


Figure 3

69. In the Figure 3 embodiment, the '067 patent states that “proxy object 302 comprise[s] one or more haptic output device(s) 118, e.g., actuators, capable of outputting a haptic effect to the user.” EX1001, 6:26-29. Like in Figure 2, Figure 3’s proxy object 302 is illustrated as a circle with no haptic output devices illustrated. The '067 patent likewise does not describe examples of proxy objects comprising haptic output devices beyond again merely using those words.

70. In the Figure 4 embodiment (below), the '067 patent states that “a user is wearing a wearable AR device 406 and a wearable peripheral device 404 and interacting with a system of proxy objects 402, which comprises at least one proxy object.” EX1001, 6:63-7:1. According to the '067 patent, a user can select different colors and textures for the “interior of a car.” EX1001, 7:4-10. The '067 patent states that the “system of proxy objects 402” (illustrated as a rectangle on

the rear of a vehicle) “may be able to accurately output haptic effects simulating the texture of the different materials without the potential buyers wearing a wearable peripheral device 404,” but does not describe means by which that would be achieved. EX1001, 7:18-22.

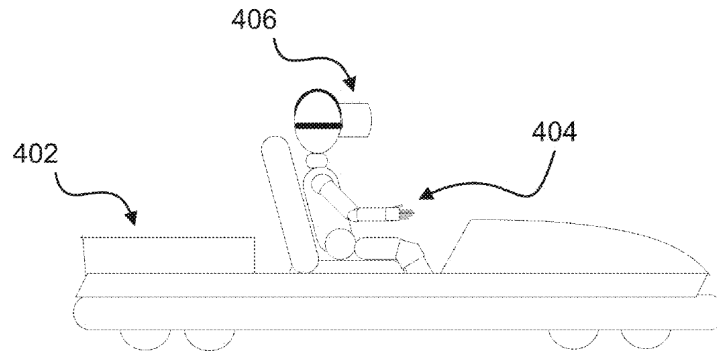


Figure 4

71. Each of the systems described in the '067 patent use well-known components in the same manner those components were conventionally and routinely used. The AR displays are generically described and illustrated as a “wearable AR device,” for which the '067 patent says “any type of AR display system” can be alternatively used. EX1001, 5:25-28.

72. Similarly, the '067 patent states that “haptic output device 118 may comprise” a laundry list of different types of known actuators (see 4:25-36), but does not describe any specific implementation, stating only that “haptic output device 118 may be integrated into a proxy object or into the user’s clothing or a wearable device.” EX1001, 4:36-38. The '067 patent discloses that the haptic

output device 118 can be used to output “thermal or kinesthetic properties” (4:39-41) and in the illustrated embodiments is used to simulate textures of materials, all of which was conventional. Indeed, the ’067 patent uses conventional components in the usual way they are employed in AR systems.

D. Prosecution History of the ’067 Patent

73. As originally filed, independent claim 1 recited a system comprising “a haptic output device,” “a display configured to output a visual effect,” “a sensor for tracking a position of a proxy object,” and a “processor” configured to, *inter alia*, cause a modified visual effect to be displayed and a haptic effect to be output. EX1002, 30. That initial claim, and others, were rejected as obvious in view of Gonzalez (EX1008) and Rimon (EX1009). EX1002, 75-103. At a high-level, Gonzalez discloses an AR system that presents a user with different “trim levels” for a car, e.g., the car’s seats can appear as leather to a user wearing an AR headset and they can feel like leather when a user touches them using an AR glove. Gonzalez (EX1008), [0006]-[0008], [0079].

74. In response, applicant amended claim 1 to require that the “haptic device” be “mechanically coupled to the proxy object” and that the display output a visual effect “onto a surface of the proxy object.” EX1002, 124. The examiner maintained the Gonzalez-Rimon rejection (EX1002, 135-170), observing that a haptic output device, like Gonzalez’s AR glove, that is “mechanically coupled” to

a proxy object, need not be the proxy object itself and thus the visual effect that must be output onto a surface of the proxy object need not be output on the glove too. EX1002, 168-169. The applicant further amended the claims to require that the haptic output device be “within” the proxy object, rather than mechanically coupled to it (EX1002, 258) and argued that the only device in Gonzalez with haptic feedback is the AR glove, but that the glove could not be the claimed “proxy object” because “the virtual objects and/or visible alterations to the vehicle are not overlaid on the AR glove.” EX1002, 264.

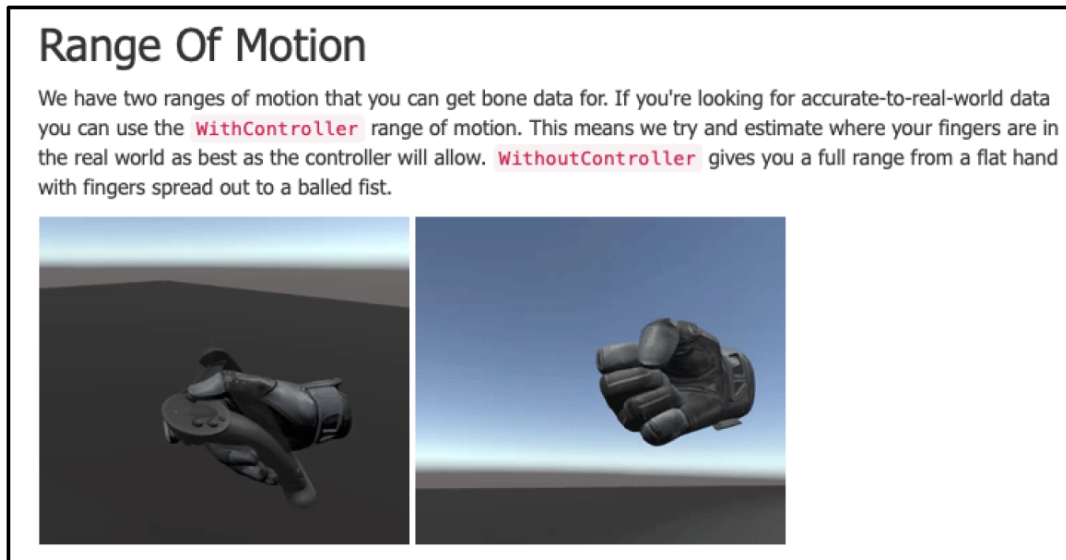
75. An examiner interview was subsequently conducted (EX1002, 284) in which the examiner agreed that further amendments requiring that the “proxy object” comprise “one or more haptic output devices” and that a “modified visual effect [] be displayed on the proxy object via the display” would place the claims in condition for allowance. EX1002, 280; *see also id.*, 285-288. The claims were then allowed. EX1002, 295.

VI. CLAIM INTERPRETATION

76. I understand that determining whether a claimed invention is novel and non-obvious requires comparing the prior art to the claim. I discuss in this Section below the interpretations I have applied to certain claim terms, in accordance with the standards set forth in Section III above.

77. I have also reviewed EX1005 (which I understand to be patent owner’s preliminary infringement contentions in the concurrent district-court proceeding) and EX1006 (which I understand is Exhibit F of the infringement contentions that includes the claim charts for the asserted claims of the ’067 patent). Based on that review, I understand patent owner to be contending that a “*visual effect*” displayed “*onto a surface of the proxy object*” recited in claim 1 and “*a modified visual effect*” displayed “*on a surface of a proxy object*” in claims 11 and 21 can be met by a wholly virtual display (i.e., where the physical environment, including the proxy object itself, is occluded). EX1006, 4-5, 31, 36.

78. Specifically, with reference to the below image capture of a display (EX1006, 5), I understand patent owner to contend that a physical video controller is the claimed “*proxy object*” and that displaying “*a visual effect onto a surface of the proxy object*” is met either by displaying a virtual hand (the alleged “*visual effect*”) grasping a ***virtual representation*** of a controller (“WithController”) or by displaying the virtual hand alone (“WithoutController”). EX1006, 4-5.



79. In my opinion, POSAs would understand patent owner’s contention to be contrary to the plain language “*onto a surface of the proxy object*” and inconsistent with the ’067 patent’s specification, which discloses “augmented reality” where the user sees a visual effect on the real world proxy object either because the user “will be able to view the proxy object with the chosen texture through the wearable AR device 204” (EX1001, 5:60-62) or will see “[t]he modified image of the proxy object through the AR display” (EX1001, 3:1-4). *See also* EX1001, 2:49-52 (“the appearance of the proxy object is modified through the AR display to show the proxy object made of the selected material”), 8:19-24.

80. The ’067 patent does not describe visual effects displayed on virtual representations of a proxy object but on the real-world proxy object itself using an AR display. Thus, in my opinion a POSA understood displaying a visual effect “*onto a surface of the proxy object*” at least requires the visual effect augments the

appearance of a real-world proxy object in a physical environment of which aspects are viewed either directly (e.g., via OST) or indirectly (e.g., via VST).

VII. GROUND 1: BANERJEE (CLAIMS 1-8, 11-12, 15-21)

81. I have been asked to provide my opinion concerning whether claims 1-8, 11-12, and 15-21 of the '067 patent are anticipated by Banerjee or would have been obvious to a POSA in light of Banerjee and the knowledge of a POSA. For the reasons explained below in §§VII.B-VII.R, it is my opinion that each of claims 1-8, 11-12, and 15-21 is anticipated by Banerjee and/or would have been obvious to a POSA over Banerjee.

82. I understand that Banerjee is prior art to the '067 patent based on Banerjee's 2012-09-27 effective filing date and 2017-04-20 publication date.

A. Banerjee (EX1011)

83. Banerjee discloses “haptic augmented and virtual reality” systems for “performing simulated surgical procedures” on virtual patient anatomy. [0027]. Banerjee discloses two system implementations: an “open surgery station” that displays “virtual reality aspects superimposed over real reality” ([0029])—i.e., Banerjee's haptic augmented reality station; and a “microsurgery station” whose visual display “consists of virtual aspects” such that “the user does not see aspects of real reality”—i.e., Banerjee's haptic virtual reality system ([0030]).

1. Open Surgery Station (OSS)

84. Banerjee's OSS allows a user to interact with objects in a 3D virtual environment (e.g., virtual patient anatomy) using a haptic stylus "as a proxy" for a "simulated surgical instrument" superimposed on the physical stylus to appear as though it were held by the user's actual hands—i.e., the physical object held in the user's hands is made to look like the particular surgical instrument that the user selected. Banerjee, [0029]. In this manner, the "user can see aspects of real reality in addition to the superimposed virtual reality aspects" while performing a surgical simulation. Banerjee, [0029].

85. OSS includes a "multi-sensorial computer interface" comprising stereoscopic vision interface 20 for superimposing virtual objects on the physical environment (i.e., for providing the user with an AR view of the surgical simulation), one or more haptic devices 22 (implemented as "haptic robot stylus 27") for tracking hand movements and providing haptic feedback to the user, and head tracking device 26 for tracking the user's visual perspective (implemented by sensors on stereoscopic goggles 43 (see EX1016, 4:8-15, which is an earlier patent also by Banerjee describing OSS 10 that Banerjee incorporates by reference)). Banerjee, [0032], [0034]-[0035], [0042]-[0043].

86. As shown by annotated FIG. 1 (below left) and as I discussed above in §V.A.2.a, OSS 10's augmented reality display implements optical see-through in

the conventional way: using an optical combiner that allows the user to view virtual objects superimposed on physical reality. Banerjee's OST display system comprises a display screen 28 angled towards partially transparent (half-silvered) mirror 30 so that user 12 simultaneously sees physical objects through the mirror (**red** arrow) and 3D-stereoscopic images of virtual objects on display screen 28 reflected by the mirror (**blue** arrow).

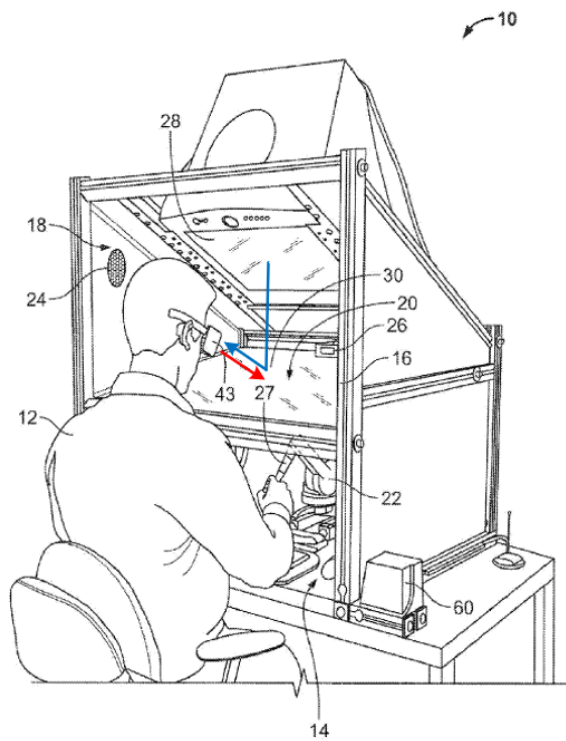


FIG. 1

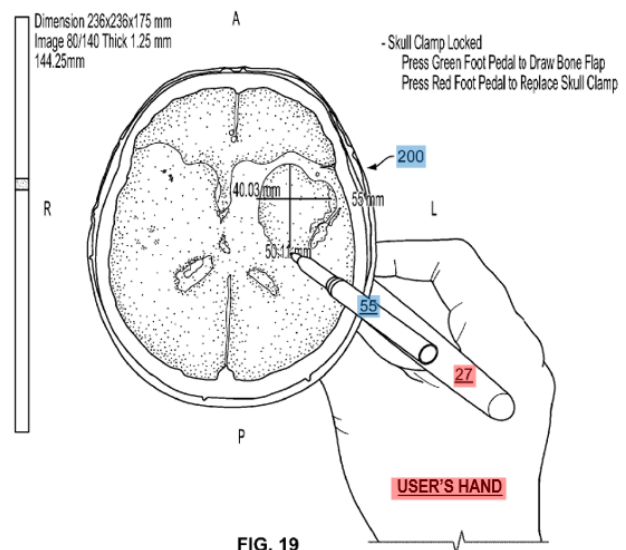


FIG. 19

87. FIG. 19 (annotated above right), for example, depicts the view seen by OSS user 12 having selected “virtual marker 55” to “mark and measure a planned craniotomy on the simulated radiology scan 200.” Banerjee, [0053]. User 12 simultaneously sees his/her actual hand holding real stylus 27 (shaded **red**) through

mirror 30 and virtual marker 55 and radiology scan 200 (annotated with blue) which are virtual objects reflected by mirror 30. In this manner, OSS 10 “automatically superimpose[s] an image of the surgical marker over the real haptic stylus 27 visible through partially transparent mirror 30,” making the stylus appear to the user like a surgical marker. Banerjee, [0053].

88. Banerjee also discloses that OSS 10’s AR display may be implemented using “Microsoft Hololens” (Banerjee, [0072]), a well-known AR head-mounted display (HMD) implementing OST as I also explained in §V.A.2.a above. *See also* EX1028, 2:25-26, 5:16-6:44. A POSA would have understood that in an OSS 10 implementation using the Hololens as the OST display system, the functionality provided by Banerjee’s display screen 28 and mirror 30 (optical combiner) would be provided by the Hololens HMD’s OST components. I discuss in further detail below (§VII.B.3, [1B]) in connection with the Hololens described in EX1028, which has functional components like the HMD optical see-through display illustrated in EX1013’s Figure 11, page 361. Banerjee’s head tracking device 26 would typically also be implemented by the Hololens’s HMD.

2. Microsurgery Station (MSS)

89. Banerjee’s MSS (see FIG. 4 below) likewise “uses a haptic stylus as a proxy for the [surgical] instrument” to allow interaction with virtual patient anatomy, but “the user does not see aspects of the real reality” and instead sees

only “computer generated graphics” of the 3D virtual environment ([0030]) via two side-by-side display screen 28 (providing a different display for each eye) and surgical eyepiece 31. Banerjee, [0035]. Because the real environment is occluded, when the user manipulates haptic styluses 27 to interact with virtual objects (e.g., virtual patient anatomy) via a selected virtual tool, the user does not see the actual stylus or the user’s actual hands, but only computer-generated objects whose virtual movements are controlled by movements of styluses 27. Banerjee, [0030].

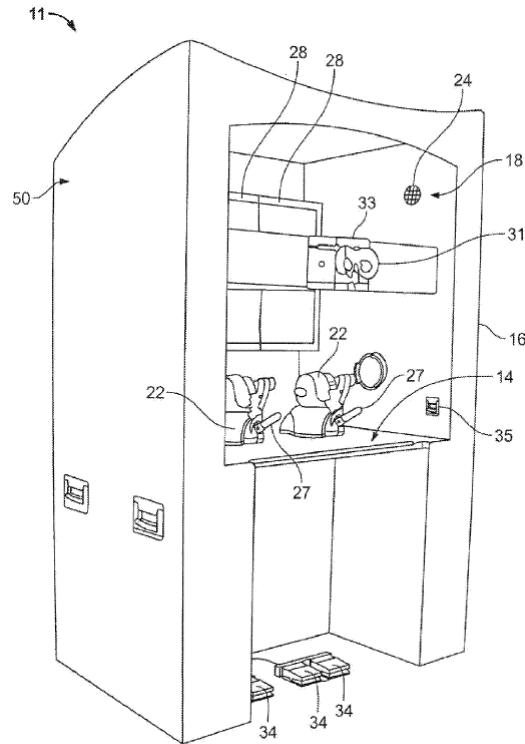


FIG. 4

3. Banerjee’s Haptics and Graphics Rendering

90. Banerjee’s OSS and MSS use the same haptics and graphics software 44, 46 (see annotated FIG. 2 below) to provide real-time haptic and visual feedback as the user manipulates a virtual tool via haptic device 22, which in both

illustrated embodiments is implemented by “haptic robot stylus 27” ([0032]-[0033]), to interact with virtual objects in a 3D virtual environment (e.g., to perform simulated surgical procedures on virtual patient anatomy) and to receive haptic feedback corresponding to that interaction. Banerjee, [0041]-[0045].

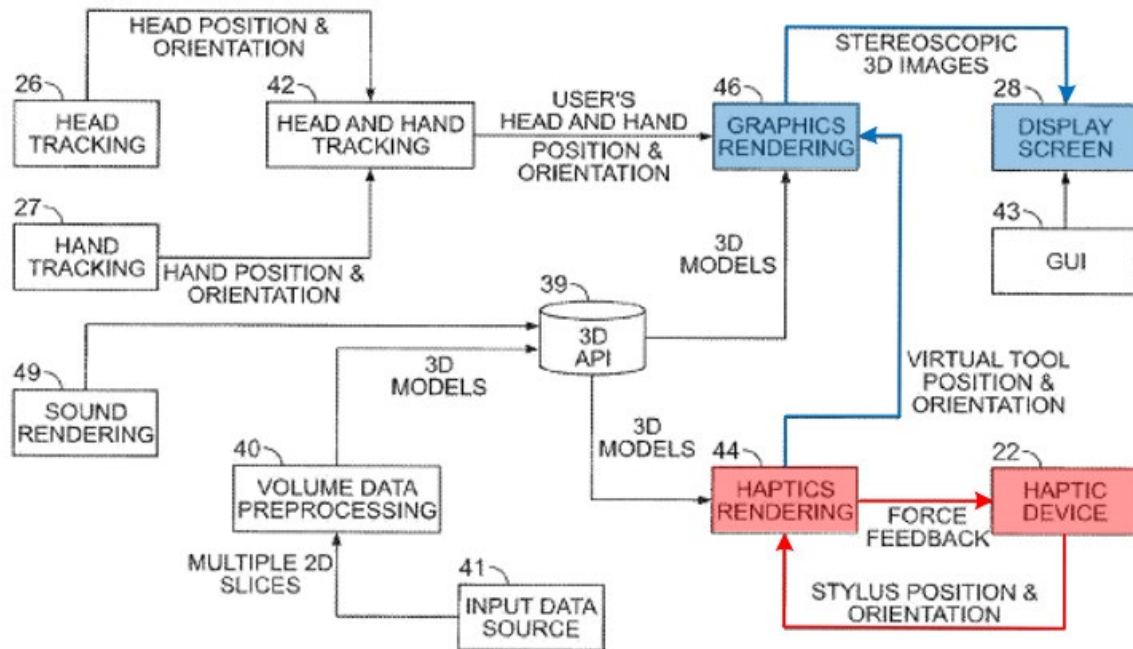


FIG. 2

91. Specifically, in the haptics update path annotated **red** in FIG. 2 above, haptics rendering 44 reads the current position and orientation of haptic stylus 27 from haptic device 22 to co-locate the virtual tool with the stylus—i.e., the location of the virtual tool in the virtual environment is updated to correspond to the physical location of the stylus in the real world. Banerjee, [0029]-[0030], [0042]. Haptics rendering 44 calculates interactions (“single or multi-point collisions”) between the virtual tool and objects in the 3D virtual environment (e.g., virtual

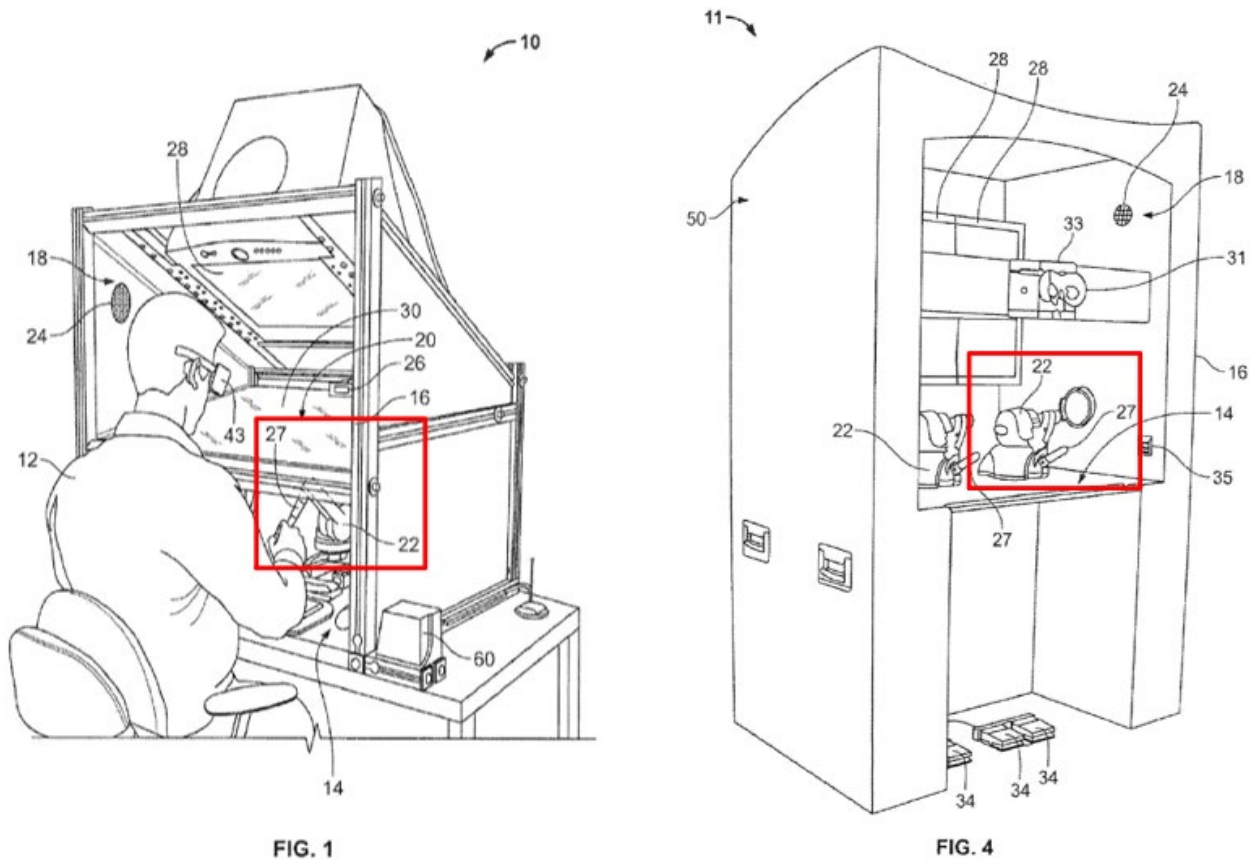
anatomy) and determines force feedback corresponding to that simulating the “feel characteristics” of the computed interactions. Banerjee, [0042]. Haptic device 22 generates the force feedback to provide “tactile sensations” ([0044]) of the computed interactions to the user holding haptic stylus 27, for example, so that the user can feel the “different sensations when touching skin, bone, and internal organs” ([0043]). Banerjee, [0042]-[0044].

92. In the graphics update path annotated **blue** in FIG. 2 above, graphics rendering 46 receives the updated virtual tool position and orientation from haptic rendering 44—i.e., the virtual tool “collocated” with haptic device 22 using the tracked position and orientation of the haptic device’s stylus 27 (and “generates and continuously updates, in real time, the stereoscopic 3D display that is displayed by a display screen 28” ([0044])—i.e., to provide the virtual aspects of OSS 10’s AR display and MSS 11’s VR display. Banerjee, [0035]-[0036], [0044].

4. Banerjee’s Haptic Device 22

93. As I discussed above, both OSS 10 and MSS 11 use haptic devices 22 implemented by haptic robot stylus 27 as the respective system’s “hand tracking device” and haptic feedback device. Banerjee, [0032] (disclosing that OSS 10 comprises “a hand tracking device in the form of at least one haptic robot stylus 27); [0033] (disclosing the same for MSS 11); [0034] (“haptic devices 22 [] track the user’s hand position and orientation and provide force feedback to the user”);

[0042]-[0044], FIG. 2 (illustrating haptic device 22 inputting the tracked “stylus position & orientation” to haptics rendering 44 and outputting the “force feedback” corresponding to computed interactions between a virtual tool and virtual patient anatomy).



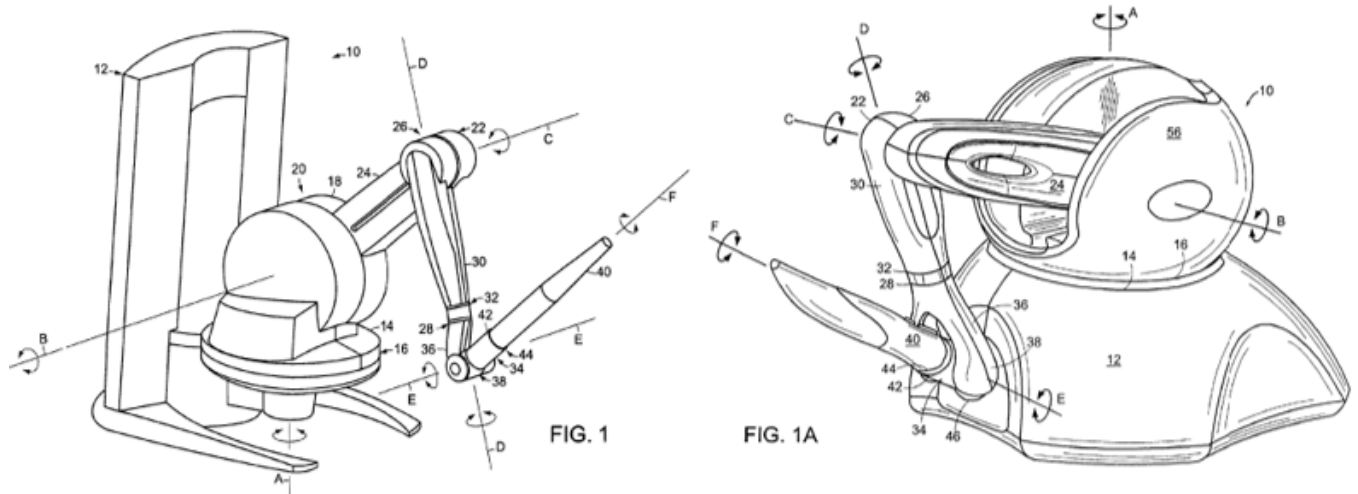
94. Banerjee’s haptic devices 22 used by OSS 10 (see annotated FIG. 1 above left) and by MSS 11 (see annotated FIG. 4 above right) are examples of well-known haptic interface devices that (1) track the position and orientation of a stylus using encoders that track rotary elements at the joints or articulations of the device (2) provide haptic feedback via a system of actuators that cause rotary elements to resist the movement of the stylus (known as force reflecting) to

simulate different sensations of contacting virtual objects. EX1017, 1:18-65; EX1018, 1:12-57. The PHANTOM® haptic devices then developed by SensAble Technologies were well-known examples of such haptic interface devices that Banerjee disclosed is the preferred implementation for haptic device 22.

95. Specifically, Banerjee discloses that “examples of open surgery stations that can be used in the present technology are described in U.S. Patent No. 7,812,815, which is hereby incorporated by reference in its entirety,” which is an earlier patent with Banerjee as a first-named inventor attached herein as EX1016. Banerjee, [0032]. EX1016 describes earlier systems that used “Sensable Technologies’ PHANTOM® Desktop™ haptic device” (3:35-36) and discloses that the preferred implementation of OSS 10’s haptic device 22 is the PHANTOM® haptic device. EX1016, 9:15-31 (“preferred haptic devise [sic] is the PHANTOM® haptic device”), see also 6:1-10:63 (describing Banerjee’s OSS 10 and haptic device 22).

96. Two configurations of the PHANTOM® haptic device are described in EX1017 and EX1018. *See, e.g.*, EX1019, [0020] (“FIG. 3 is a schematic representation of a PHANTOM® force-feedback haptic interface device”), FIG. 3 (illustrating the same drawing as FIG. 1 of EX1017). As shown in FIG. 1 of EX1017 (below left) and FIG. 1A of EX1018 (below right), these two

configurations correspond to OSS 10's and MSS 11's haptic devices 22, respectively (see Banerjee's FIGS. 1 and 4 above, respectively).



97. The “haptic interface 10” (EX1017, 4:26-28; EX1018, 5:54-60) disclosed in both patents track a stylus 40 and provide haptic feedback in the same general way—by using a system of optical encoders and actuators, respectively. Both haptic interfaces 10 include six joints or articulations (16, 20, 26, 32, 38 and 44) each having a corresponding rotary element (14, 18, 22, 28, 34, 40) to allow a stylus 40 to be maneuvered in free space with six degrees of freedom. EX1017, 1:41-65, 4:26-54 (“FIG. 1 is a schematic perspective view of a six degree of freedom force reflecting haptic interface 10”); EX1018, 1:34-57, 5:54-6:21 (“FIG. 1A is a schematic perspective view of a six degree of freedom force reflecting haptic interface 10”).

98. Each of the stylus's degrees of freedom “can be tracked using an encoder, potentiometer, or other measurement device” that together determines the

spatial location of stylus 40 (EX1017, 1:53-56; EX1018, 1:45-48). Each degree of freedom may be tracked by measuring the angular location of corresponding rotary elements at respective articulations. EX1017, 2:66-3:5 (disclosing the use of an “optical encoder” to track powered rotary elements), 12:64-13:10 (same), 13:18-34, 13:43-46 (disclosing using “potentiometers” to track non-powered rotary elements); EX1018, 3:51-55, 12:54-13:12.

99. Both haptic interfaces 10 provide force feedback by powering rotary elements using a “motor or other actuator” to resist movement of stylus 40 along the corresponding degree of freedom (EX1017, 1:43-49; EX1018, 1:36-42).

EX1017, 1:61-65, 4:26-59, 12:64-13:10, 15:15 (disclosing embodiments “where the actuators are DC motors”); EX1018, 1:53-57, 3:38-46, 5:54-6:36, 12:54-13:12, 13:14-15 (disclosing each “actuator 303 is a D.C. motor”), 13:26-29, 16:5-13.

B. Claim 1

1. [1PRE]: “A system comprising:”

100. Banerjee discloses “haptic augmented and virtual reality [] *systems*” that include “open surgery station 10” and “microsurgery station 11” (i.e., the OSS and MSS that I discussed above in §VII.A when describing Banerjee’s surgical simulation system). Banerjee, [0027]-[0031]. Banerjee discloses that OSS 10 and MSS 11 can share computer 32 and describes using each system for different steps of a surgical procedure. Banerjee, [0037], [0052]-[0059], [0063]-[0068]

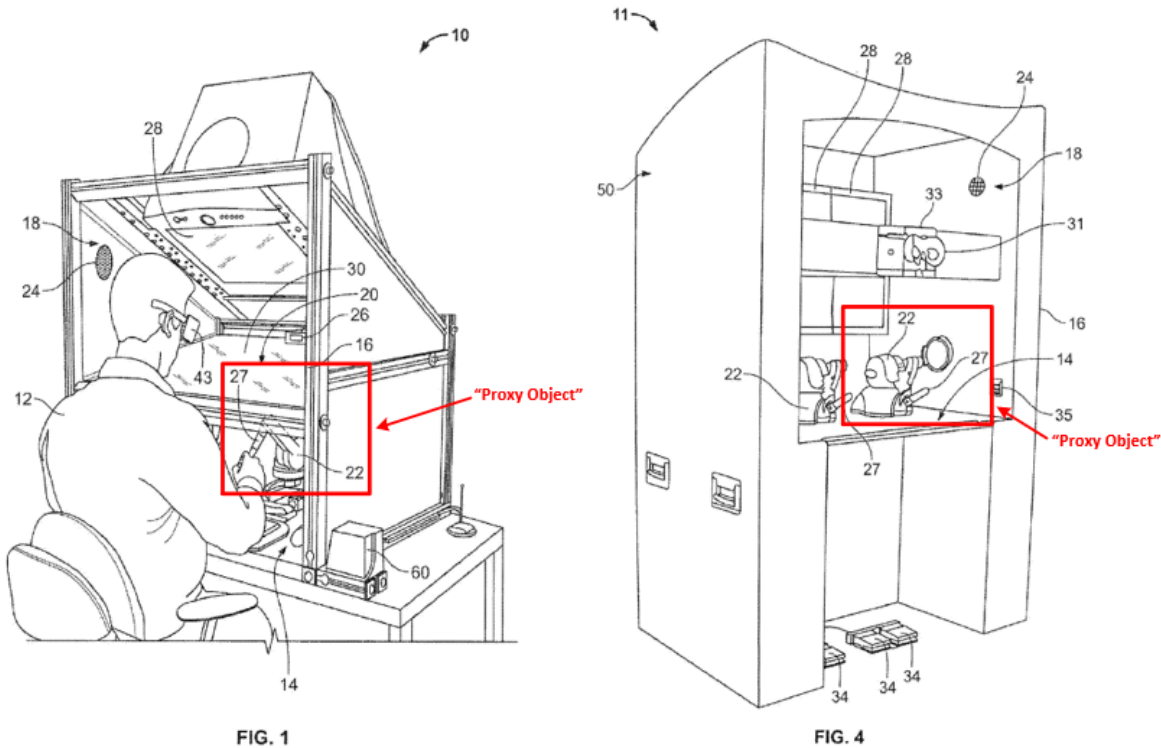
(describing performing a series of surgical steps using OSS 10), [0060]-[0062] (describing switching over to MSS 11 to perform steps requiring the use of two surgical tools). The combined OSS/MSS system and/or either system individually meets [1PRE]. Banerjee, [0031].

2. [1A]: “a proxy object comprising one or more haptic output devices,”

101. In my opinion, a POSA would have understood that Banerjee’s haptic device 22 (or its component haptic stylus 27) used “as a proxy” for a surgical tool meets [1A]. Banerjee, [0029]-[0034].

a. Haptic Device 22 Meets [1A]

102. As boxed in **red** in annotated FIGS. 1 and 4 below, both OSS 10 and MSS 11 implement haptic device 22 via haptic robot stylus 27 to track the position and orientation of the user’s hand as it moves the stylus. This tracking allows a virtual tool to be “collocated with [] haptic device 22.” Banerjee, [0032]-[0034].



103. In this way, the user holds and manipulates haptic device 22’s stylus 27 “as a proxy” for the virtual tool that the user is controlling in the AR simulation to interact with virtual patient anatomy. Banerjee, [0029]-[0030]; *see also* [0032]-[0034], [0042], [0053]-[0070]. Thus, Banerjee’s haptic device 22 is a real-world object that Banerjee explicitly says is a “proxy,” and that the user manipulates to control a corresponding virtual tool that a POSA understood is a “*proxy object*” as claimed, as I discussed in §V.B above.

104. Haptic interface 22 is also a “*proxy object*” as described in the ’067 patent, which says that the proxy object “may take the form of any object” (as I also discussed in §V.B above) and gives “an interface object” and an “electronic device” as example proxy objects. EX1001, 5:34-37. Banerjee’s haptic devices 22

are both. Specifically, haptic device 22 *is* the interface between the physical and virtual environment, providing both hand tracking and haptic feedback. Banerjee, [0032]-[0034], [0042]-[0044]. That is, haptic device 22 with its haptic stylus 27 is an object that “provide[s] information regarding the user’s interaction with the system” ([0032]-[0033]) both to and from the simulation—i.e., haptic device 22 and haptic stylus 27 (discussed below) are each a claimed “interface object” because they each provide an interface with the user that collects the positional information that controls the virtual tool and by which interaction with virtual anatomy is computed, and provides the corresponding haptic feedback to the user. [0032]-[0044].

105. Haptic device 22 is also an “electronic device” because it comprises sensors (e.g., encoders, potentiometers, etc.) and actuators (e.g., DC motors) that are electrically powered, as I discussed in §VII.A.4 above. *See, e.g.*, EX1017, 4:26-54 (describing “powered” rotary elements); EX1018, 5:54-6:28 (same), 6:29-36 (power connection “supplies electrical power to the interface 10 to operate internal components, including control circuitry, sensors, actuators and display elements”). Thus, haptic device 22 also meets [1A]’s “*proxy object*” for at least the reasons the ’067 patent’s embodiments do.

106. Haptic device 22 “*compris[es] one or more haptic output devices*” for multiple reasons. First, haptic device 22 is a haptic output device because it is

explicitly described as a “haptic device,” and it outputs the “force feedback” corresponding to the computed interaction between the virtual tool and virtual patient anatomy to simulate the “feel characteristics” of the virtual patient anatomy contacted by the virtual tool. Banerjee, [0042] (“characteristics of the various 3D structures will, with the interface to [] haptic device 22, present different feel characteristics in the virtual reality environment, e.g. skin will feel soft and bone hard.”).

107. Second, haptic device 22 comprises haptic stylus 27, which is a haptic output device because the force feedback generated by haptic device 22 is output to the user via its haptic stylus 27—i.e., the user feels the haptic device’s output “tactile sensations” through stylus 27 ([0044]). Banerjee, [0042] (“Therefore, the user 12 can feel the different surfaces and textures of objects and surfaces in the virtual environment”), [0043] (“In a surgical simulation example, the user 12 can feel different sensations when touching skin, bone, and internal organs, such as the brain”), [0044] (“the user can feel tactile sensations with a hand holding a haptic stylus 27”). Indeed, as I discuss in further detail in §VII.B.5.b below, Banerjee discloses numerous examples where haptic rendering 44 computes forces corresponding to different haptic effects for interactions between different virtual tools and virtual patient anatomy and “outputs the force result to the haptic stylus 27.” Banerjee, [0057]-[0059], [0062]-[0063], [0068].

108. Third, as I discussed in §VII.A.4 above, a POSA understood that Banerjee’s FIG. 1 and 4 haptic devices 22 are examples of well-known haptic interface devices that provide haptic feedback via a system of actuators that resist the movement of the stylus (i.e., a “force feedback,” [0042]) to simulate different sensations of contacting virtual objects (i.e., like the PHANTOM® haptic device that Banerjee, via incorporation by reference, discloses is the preferred implementation of its haptic device 22), examples of which are disclosed in EX1017 and EX1018. *See e.g.*, EX1017, 1:45-65, 4:55-58, 12:64-13:10, 15:15 (disclosing embodiments “where the actuators are DC motors”); EX1018, 1:38-57, 3:38-46, 12:54-13:12, 13:14-15 (disclosing each “actuator 303 is a D.C. motor.”), 13:26-29, 16:5-13; Banerjee, [0032]; EX1016, 9:15-31; EX1019, [0020], FIG. 3. Thus, haptic device 22 meets [1A] for the additional reason that it comprises actuators.

109. Even if Banerjee had not disclosed that its haptic devices 22 include actuators (e.g., motors), that would have been an obvious and conventional way to implement the disclosed haptic devices (e.g., by using the PHANTOM® haptic interface as Banerjee discloses). EX1016, 9:15-31; Banerjee, [0032].

b. Haptic Stylus 27 Meets [1A]

110. Haptic device 22’s haptic stylus 27 also meets [1A]’s “*proxy object*” because it is a real-world object used “as a proxy” to control a virtual tool, just like

haptic device 22 of which it is a part. [0029]-[0030]. Haptic stylus 27 “*comprises one or more haptic output devices*” both because it is itself a “*haptic output device*” through which “tactile sensations” are felt ([0044]) as I discussed immediately above, and because a POSA would have understood that haptic stylus 27 comprises the actuators (i.e., “*haptic output devices*”) discussed above that cause the disclosed force feedback felt by the user holding the haptic stylus 27. Banerjee, [0032], [0042]-[0044]; EX1017, 1:45-65, 4:55-58, 12:64-13:10, 15:15; EX1018, 1:38-57, 3:38-46, 12:54-13:12, 13:14-15, 13:26-29, 16:5-13; EX1016, 9:15-31.

111. Specifically, the actuators are the part of the haptic stylus 27 device that cause the force feedback to be felt because haptic stylus 27 is mechanically coupled to, and thus comprises, the actuators that produce the resistance forces.

3. [1B]: “a display configured to output a visual effect onto a surface of the proxy object;”

112. In my opinion, a POSA would have understood that Banerjee’s system meets [1B] because OSS 10’s display system displays “virtual reality aspects superimposed over real reality” (Banerjee, [0029]). Banerjee, [0032], [0035], [0053]-[0059]. Alternatively, MSS 11’s VR display also meets [1B] under patent owner’s broad interpretation that [1B] covers virtual-only displays.

a. OSS 11 Meets [1B]

113. As illustrated in FIG. 1 annotated below, OSS 10's display system comprises an overhead "display screen 28" (shaded **blue**), which may be a "single passive stereo monitor" ([0035]), that displays stereoscopic images of the virtual aspects of the environment above a "half-silvered mirror 30" (shaded **purple**) "to reflect the image of the display screen" to the user. Banerjee, [0035]. Because half-silvered mirror 30 is "partially transparent," the user also sees the physical environment (i.e., "the user's hands" and "haptic device 22 with its stylus 27") through half-silvered mirror 30 to provide "an augmented reality environment." Banerjee, [0035].

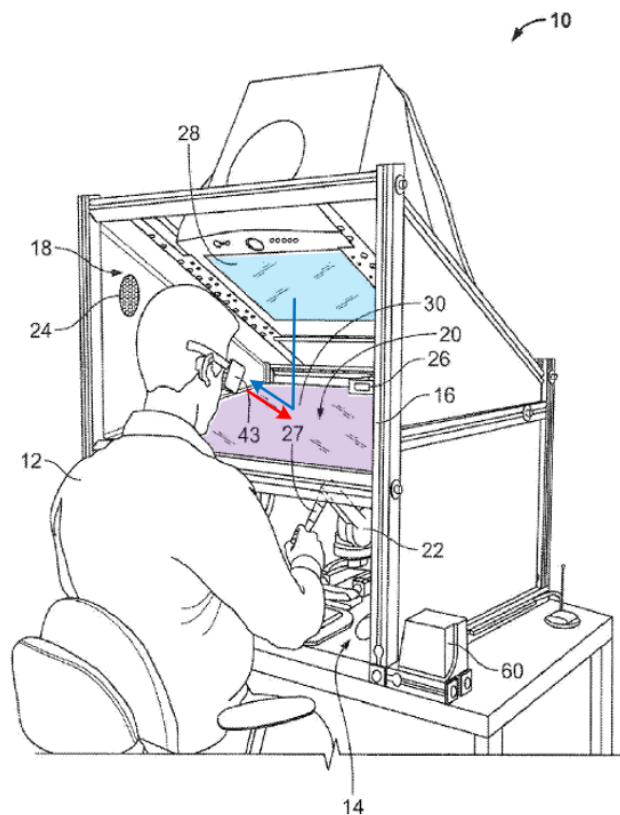
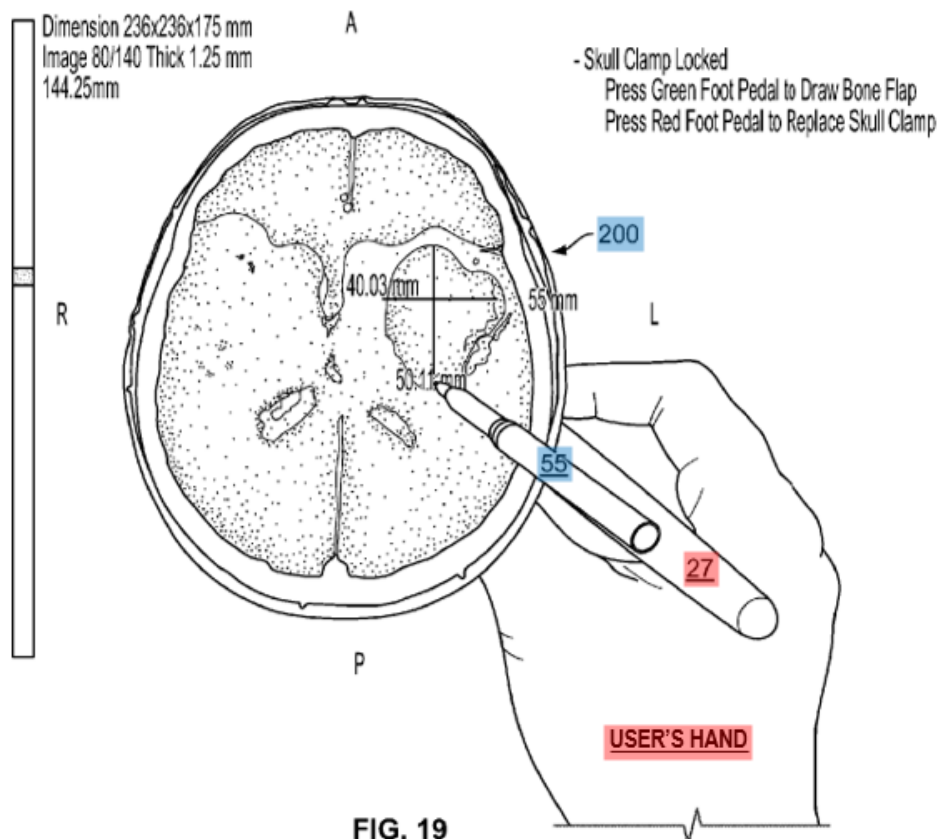


FIG. 1

114. The “virtual reality display” from screen 28 includes a 3D image of a virtual tool selected by the user that has been co-located with haptic device 22 such that when the user holds stylus 27, the 3D image of the virtual tool reflected by half-silvered mirror 30 appears to be held in the user’s actual hand seen through half-silvered mirror 30. Banerjee, [0029], [0034]-[0035], [0042]-[0044]. FIG. 19 illustrates an example of this visual effect in the case where the user has selected a virtual surgical marker 55 to “mark and measure a planned craniotomy.” Banerjee, [0053].



115. As shown by FIG. 19 (annotated above with virtual object labels shaded **blue** and real object labels shaded **red**), user 12 simultaneously sees both the virtual objects (i.e., “simulated radiology scan 200” and “virtual marker 55”) as reflected by half-silvered mirror 30 from display screen 28, and the real environment through half-silvered mirror 30 (i.e., the user’s hand (label added) and haptic stylus 27 on which virtual marker 55 is superimposed). Banerjee, [0053]. Banerjee also discloses numerous other surgical tools (see FIGS. 7-18) that user 12 can select to perform different surgical procedures on virtual patient anatomy where OSS 10’s display system automatically “superimpose[s] an image of the tool over the real haptic stylus 27 visible through partially transparent mirror 30” ([0057]). Banerjee, [0034]-[0035], [0044], [0057]-[0059], [0062]-[0063], [0068].

116. Thus, OSS 10’s display system is “*configured to output a visual effect onto a surface of the proxy object*” as a POSA would have understood [1B] as I discussed above in §VI because the image of the virtual tool (“*a visual effect*”) is “superimpose[d] over the real haptic stylus 27 visible through partially transparent mirror 30” (Banerjee, [0053], [0057]-[0059], [0063])—i.e., “*onto a surface of the proxy object*” like the ’067 patent’s embodiments where visual effects are seen on the proxy object “through” the AR display. EX1001, 2:49-52, 5:60-62, 8:19-24; Banerjee, [0029], [0035], [0044], [0068].

117. OSS 10's display system also meets [1B] under patent owner's broader interpretation that [1B] is met by displaying virtual objects without displaying any aspect of the physical environment—i.e., that [1B] encompasses both AR and VR displays. Specifically, as I discussed above in §VI, I understand patent owner to contend that [1B] is met by displaying virtual hands (the alleged “*visual effect*”), with or without displaying a virtual representation of the proxy object. EX1006, 4-5. Thus, OSS 10's display system (or any of its component parts) meets [1B] because it is configured to display the image of the virtual tool. Banerjee, [0034]-[0035], [0053]-[0059], [0063]-[0068].

118. A POSA would have understood that OSS 10's “display system” ([0035]) that is implemented by display screen 28 and mirror 30, meets [1B]'s “*display*,” just like many conventional AR displays are implemented using a combination of elements as I discussed in §V.A.2 above. Indeed, the '067 patent explicitly says that “AR headsets” are a type of display (EX1001, 3:40-41), which AR headsets a POSA would have understood commonly included the same elements as OSS 10's display system, e.g., EX1013's head-mounted OST display (EX1013, 361-362, Figures 11-12), the Hololens AR headset (Banerjee, [0072]; EX1028, 2:25-26, 5:16-6:44, FIGS. 2-5), or Google Glass discussed in §V.A.2.a. See also EX1001, 5:60-62, 8:19-24 (disclosing the “wearable AR device” shown as a headset in FIGS. 2-4 is an “augmented reality display”).

119. Thus, a POSA would have understood that “*a display*” encompasses multi-element AR displays for at least these reasons. This understanding is reinforced by the ’067 patent’s disclosure that while FIG. 2 “shows the user wearing a wearable AR device 204, any type of AR display system may be used.” EX1001, 5:26-28. Moreover, Banerjee discloses that the OSS’s display system can be implemented using the “Microsoft Hololens” ([0072])—i.e., an AR headset that the ’067 patent explicitly says is a display (EX1001, 3:40-41, 5:60-62, 8:19-24). EX1028, 2:25-26, 5:15-6:44, FIGS. 2-5.

120. Specifically, a POSA would have understood that Banerjee’s disclosure that OSS 10’s display system can be implemented using the Microsoft Hololens ([0072]) means that OSS 10’s display screen 28 and half-silvered mirror 30 would be replaced by the Hololens HMD’s OST components as I noted above in §VII.A.1. For example, FIG. 2 (below) of EX1028 (Microsoft’s patent no. 10,146,335) shows the “Microsoft Hololens” (EX1028, 2:25-26), which is described as an example of a “head mounted display (HMD)” (EX1028, 1:12, 5:16-17) comprising “see-through holographic lenses that use an advanced optical projection system to generate multi-dimensional full-color holograms” so that “a user can see holographic objects in a real world setting” (EX1028, 5:18-22).

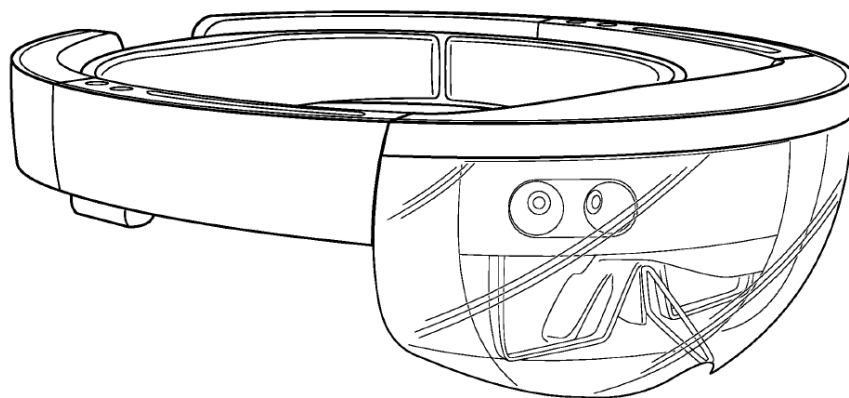


FIG. 2

121. A POSA would have understood that in Banerjee's disclosed Hololens implementation of OSS 10's display system, the function of Banerjee's mirror 30 would be implemented by the Hololens's see-through holographic lenses (i.e., "a pair of transparent combiner lenses" within the Hololens's "visor," EX1028, 5:36-37), and the function of Banerjee's display screen 28 would be performed by the Hololens's "optical projection system" (EX1028, 5:20). EX1028, 2:25-26, 5:15-6:44. I have used the Hololens as the OST display to implement augmented reality systems (see EX1037) and I was very familiar with the Hololens HMD before the '067 patent as practitioners in AR would have been expected to be given that Hololens was a well-known and oft-used AR headset. In my opinion, a POSA would have understood how Banerjee's OSS display system would have been implemented using the Hololens and would have known how to do so with a

reasonable expectation of success in the manner described above, just as Banerjee discloses it could (Banerjee, [0072]).

122. Accordingly, Banerjee discloses an implementation in which OSS 10's display system is incorporated as a "head mounted *display* (HMD)" (EX1028, 1:12, 5:16-17). Thus, OSS 10's display system implemented as shown in FIG. 1, or implemented as the Hololens HMD, meets "*a display configured to output a visual effect onto a surface of the proxy object.*"

123. Alternatively, display screen 28 alone also meets [1B]'s "*display*" because it is "*configured*" to output the claimed "*visual effect*" by being arranged and oriented relative to mirror 30 in the manner disclosed, thus causing virtual tool to appear superimposed on the surface of the physical stylus. Banerjee, [0035], [0053], [0057]-[0059], [0063], [0068]. Similarly, Banerjee's mirror 30 (i.e., Banerjee's optical combiner) alone also meets [1B]'s "*display*" because it displays the "*visual effect*" that the user sees by reflection and the real world via transmission. Banerjee, [0035]; see also EX1028, 3:1-17 (referring to the optical combiner of an OST HMD device 10 as the "stereoscopic display 12"), FIG. 1.

b. MSS 11 Meets [1B] Under Patent Owner's Interpretation

124. Additionally, MSS 11's display screen 28 (shaded **blue** in Figure 4 below) displays only the "virtual aspects" of the simulation (Banerjee, [0030]) and

meets [1B] under patent owner's broad interpretation that [1B] covers VR displays.

Banerjee, [0030], [0035], [0042]-[0044]; EX1006, 4-5; §VI.

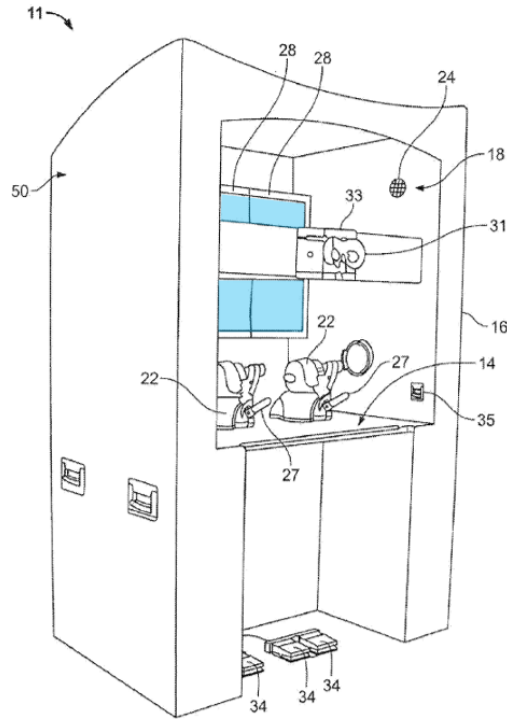


FIG. 4

125. Specifically, MSS 11's "visual display provided to a user [that] consists of virtual aspects, which are computer generated graphics" where the "user can interact with displayed virtual patient anatomy using displayed virtual surgical instruments" ([0030]) meets [1B] in the same way that patent owner alleges displaying virtual hands with or without displaying a virtual controller meets [1B]. EX1006, 4-5.

4. [1C]: “a sensor for tracking a position of the proxy object;”

126. In my opinion, a POSA would have understood Banerjee’s system meets [1C] because haptic device 22 tracks the position and orientation of its haptic stylus 27 in both OSS 10 and MSS 11.

127. Specifically, OSS 10 and MSS 11 each include a “haptic device 22” to “track the user’s hand position and orientation.” Banerjee, [0034]. This is achieved by haptic device 22 tracking the real-time position and orientation of its stylus 27 being held by the user. Banerjee, [0029]-[0034], [0042]. As shown in FIG. 2 below with **red** emphasis, haptics rendering 44 reads the current position and orientation of stylus 27 from haptics device 22 to collocate the virtual tool with haptic device 22 in real time. Banerjee, [0042]-[0044].

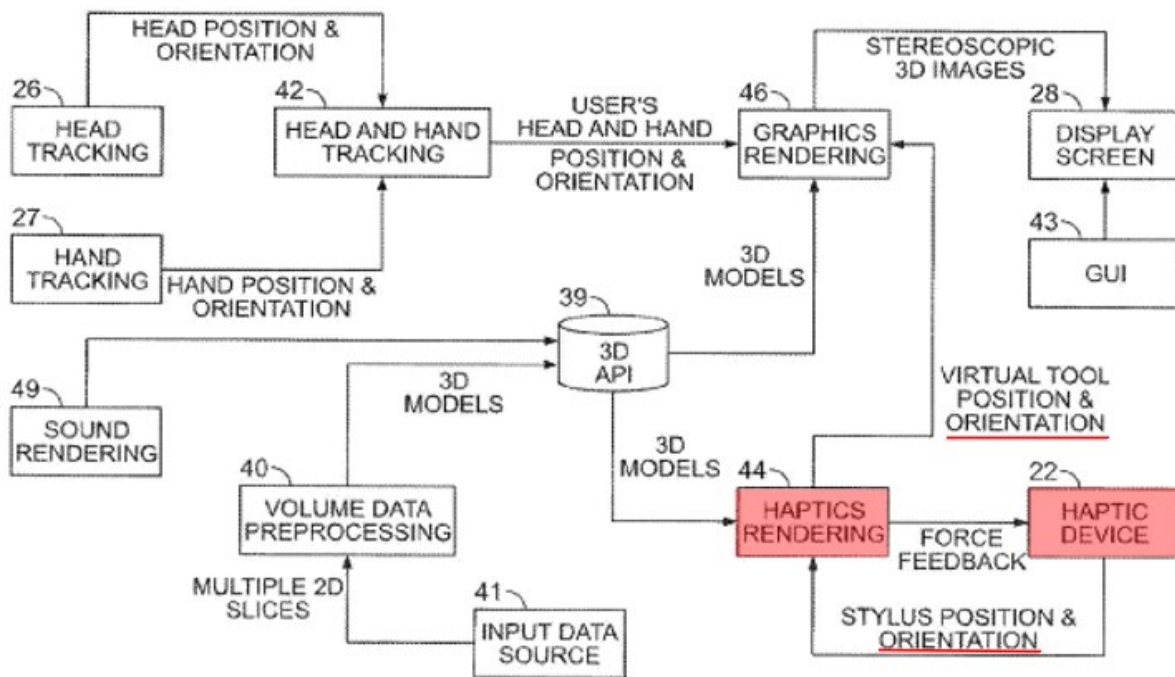


FIG. 2

128. A POSA thus understood Banerjee’s haptic device 22 that continuously detects the position and orientation of its stylus and that implements OSS/MSS system’s “hand tracking device” is (or includes as discussed below) a “*sensor*,” which the ’067 patent uses broadly to cover a whole range of devices (e.g., cameras, lasers, radars, microphones, etc.), including “tracking sensors” that perform the tracking function as Banerjee’s haptic device 22. EX1001, 4:2-8. As one example, the ’067 patent discloses that “detection module 124 may sample sensor 108 in order to track [] the location [] of haptic output device 118 over time” (EX1001, 4:52-55), just like Banerjee’s haptic rendering 44 samples haptic device 22 (e.g., at 1000 Hz) to track the position and orientation of haptic stylus 27 in real time. Banerjee, [0043]-[0044]. As another example, the ’067 patent discloses that “controllers or input devices may be the user’s hands, and sensors 108 may be able to detect the movements and gestures in free space” (EX1001, 3:49-51), just like Banerjee’s haptic devices 22 “track the user’s hand position and orientation” ([0034]).

129. Haptic device 22 tracks “*a position of the proxy object*” for multiple reasons. First, the tracked position/orientation of haptic stylus 27 is “*a position*” of haptic device 22 (which is a claimed “*proxy object*” as I discussed above in §VII.B.2.a) of which the stylus is a part—i.e., “haptics rendering software 44 can read the position and orientation of each haptic device 22, for example a stylus 27”

([0042]). Second, as I discussed above in §VII.B.2.b, haptic stylus 27 itself also meets [1A]’s “*proxy object*” and thus haptic device 22 “*track[s] a position of the proxy object*” by tracking the current position and orientation of its stylus.

Banerjee, [0032]-[0034], [0042].

130. Additionally, a POSA would have understood that haptic device 22 includes individual sensors (e.g., optical encoders or potentiometers) that track movement of each articulating joint that defines the stylus’s location in space—e.g., like the optical encoders and potentiometers that measure the angular location of corresponding rotary elements at respective joints in the haptic interface devices described in EX1017 and EX1018, which as I discussed above in §VII.A.4, are examples of the PHANTOM® haptic device that Banerjee discloses via incorporation by reference is the preferred implementation of haptic device 22 (or that alternatively would have been an obvious and conventional implementation of Banerjee’s disclosed haptic devices 22). *See* EX1017, 1:18-56, 2:66-3:5, 12:64-13:46; EX1018, 1:12-49, 3:51-55, 12:54-13:12; Banerjee, [0032]-[0034], [0042]; EX1016, 9:15-31; EX1019, [0020], FIG. 3.

131. Each optical encoder (which are “light sensors” that the ’067 patent gives as an example sensor, EX1001, 4:4) or potentiator is “*a sensor*” that tracks “*a position*” of the haptic device 22 (a claimed “*proxy object*” as I discussed in §VII.B.2.a above) at the corresponding joint, thereby also tracking “*a position*” of

the haptic stylus 27 (also a claimed “*proxy object*” as I discussed in §VII.B.2.b above) in space. Thus, Banerjee’s system meets “*a sensor for tracking a position of the proxy object*” for these additional reasons.

5. [1D]: “a processor configured to:”

132. In my opinion, a POSA would have understood that Banerjee’s computer 32 that executes the haptics and graphics rendering software for both the OSS and MSS includes “*a processor*” as claimed. Banerjee, [0037]-[0040].

133. Computer 32 (boxed in **red** in FIG. 3 below) is “operatively connected” to both OSS 10 and MSS 11, or alternatively, each can be “operatively connected to a separate computer 32.” [0037]. Computer 32 includes the software that “controls and operates” both OSS 10 and MSS 11 ([0037]) to “provide real-time simulation” ([0038]-[0039]) that performs limitations [1D1]-[1D5] as discussed in further detail.

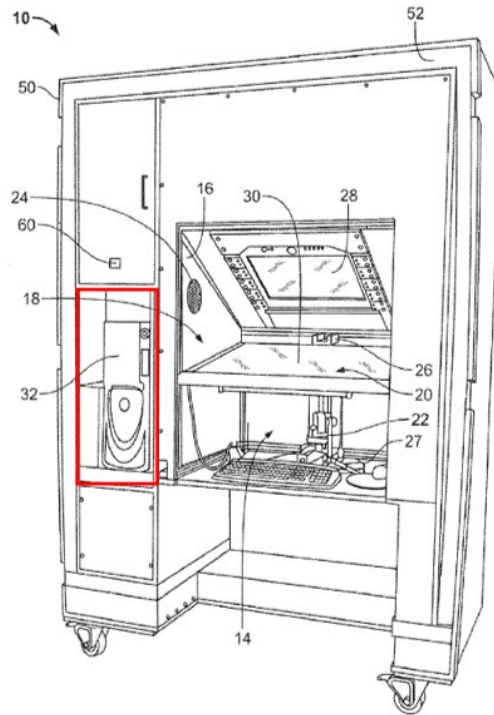


FIG. 3

134. Specifically, computer 32 includes haptics rendering software 44 (“haptics rendering logic that drives each haptic device,” [0038]-[0039]), graphics rendering software module 46 (“graphics logic that drives the display system,” [0038]-[0039]), and the 3D application programming interface (API) 39 (“software library,” [0037]) that integrates the software modules with the hardware device (OSS/MSS “logic [that] integrate[s] the haptics rendering logic and the graphics logic and provide[s] real-time simulation” of the surgical steps of a surgical procedure performed on OSS 10 and MSS 11, [0038]-[0039]), as shown in FIG. 2.

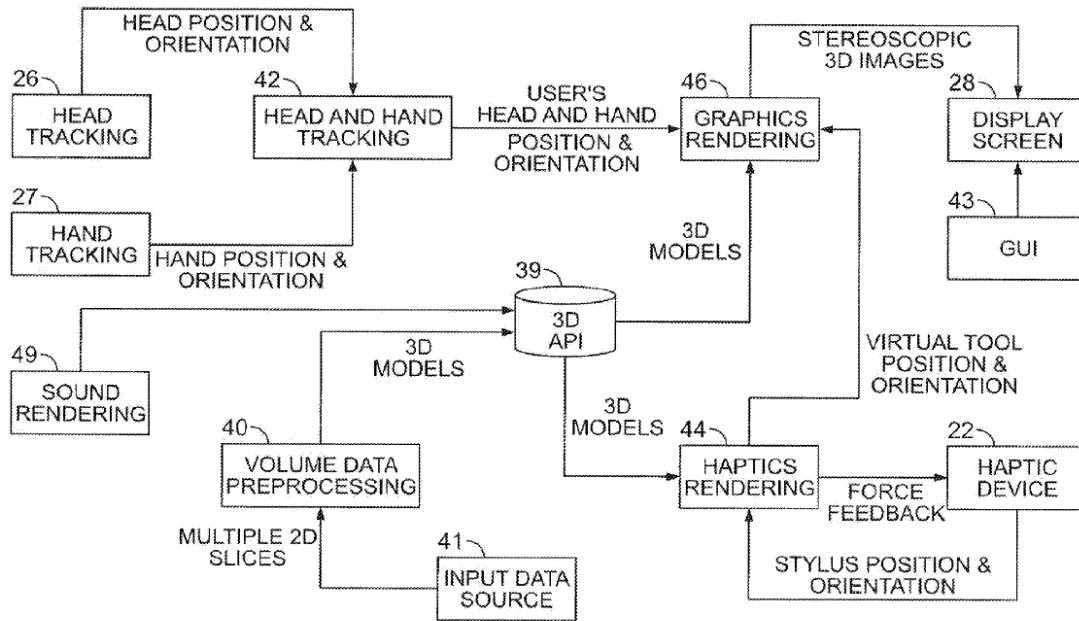


FIG. 2

135. A POSA would have understood that computer 32 includes “a processor” as claimed to execute the software modules that Banerjee discloses are included therein, and therefore meets [1C]’s *processor*. Banerjee, [0037]-[0040], [0043]. For example, Banerjee discloses that in “a preferred embodiment, the graphics and haptics can be on two separate threads, which can be implemented, for example with a dual processor computer.” Banerjee, [0043]. A POSA would have understood Banerjee’s example “dual processor computer” to also meet [1C]’s *processor*—i.e., two processors that work together to perform the claimed functionality.

136. The ’067 patent discloses that the steps in FIG. 5’s method for “integrating haptics overlay in augmented reality” that correspond to limitations

[1D1]-[1D5] may be “implemented by a group of processors” (7:39-44). EX1001, 7:35-8:49. The ’067 further states that “[t]he processor, and the processing, described may be in one or more structures, and may be dispersed through one or more structures” (10:24-26), reinforcing the POSA’s understanding that the claimed “*a processor*” encompasses multiple processors that work together to perform the claimed functionality. That is, the processor and the processing may be “dispersed” with one processor structure (e.g., a chip or package) performing some of the processing steps and another processor structure (e.g., a different chip or package) performing others of the processing steps.

137. Additionally, a POSA would have understood that both of Banerjee’s example dual processors are configured to perform the claimed functionality because each processor can execute either the haptics thread or the graphics thread—i.e., both processors can execute any program generally as processors are configured to do, and so both are “*configured to*” perform limitations [1D1]-[1D5].

138. Furthermore, as Banerjee discloses, a “dual processor computer” is merely an “example” way in which Banerjee’s preferred dual-thread embodiment could be implemented. Banerjee, [0043]. As another example, a POSA would have understood that Banerjee’s preferred dual-thread embodiment could also be implemented on a dual core processor (or a multi-core processor with more than two cores), which was another conventional and common processor

implementation for simultaneously executing multiple threads. For example, Meglan (EX1012) discloses that its “processor 60” that executes program 90 that controls the graphics and haptics for its trauma simulator “may include multiple cores for simultaneously processing a variety of computational threads associated with the use of program 90,” including “dual-core processors.” Meglan, [0103].

139. The obvious implementation of computer 32 using a dual-core processor meets [1D]’s “*processor*” even if this limitation is interpreted as being limited to a single processor. Moreover, POSAs understood that “the graphics and haptics” could be executed on the same thread using a single processor computer. This understanding is reinforced by Banerjee’s disclosure that a dual thread embodiment is merely “preferred” and in which “the graphics and haptics *can* be on two separate threads,” implying precisely what a POSA would have understood—i.e., that a single thread/single-core processor implementation could also be used. Banerjee, [0043].

140. Banerjee’s processor, whether implemented as the example dual processor or as any of the above-described obvious processor implementations, meets [1D]’s “*processor*” and performs limitations [1D1]-[1D5] when it executes “haptics rendering software 44” and “graphics rendering software 46” ([0042]-[0044]), as I discuss in §§VII.B.5.a-VII.B.5.e below.

a. [1D1]: “determine a modified visual effect based in part on data received from the sensor;”

141. In my opinion, a POSA would have understood that Banerjee’s processor (see §VII.B.5) performs [1D1] each time graphics rendering software 46 updates in real time the display of the 3D image of the virtual tool based on the current position and orientation of stylus 27 received from haptic device 22. Banerjee, [0042], [0044].

142. As shown by the graphics update path annotated in blue in FIG. 2 below, “graphics rendering 46” receives the current position and orientation of the virtual tool updated by “haptic rendering 44” to coincide with the current position and orientation of stylus 27 received from haptic device 22 (see §§VII.A.3, VII.B.4 above and VII.B.5.b below). Banerjee, [0042]-[0044].

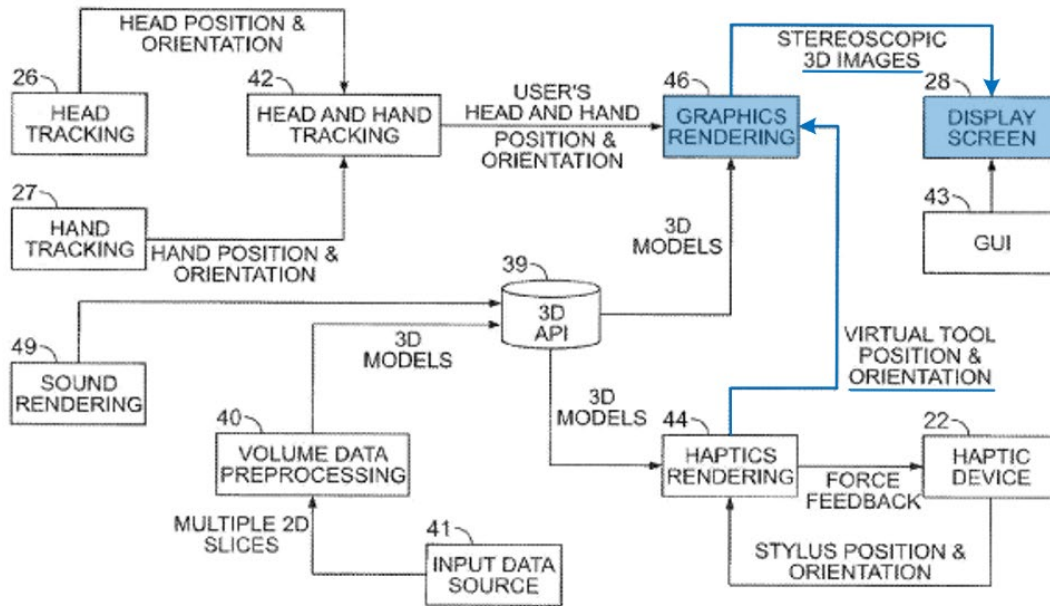
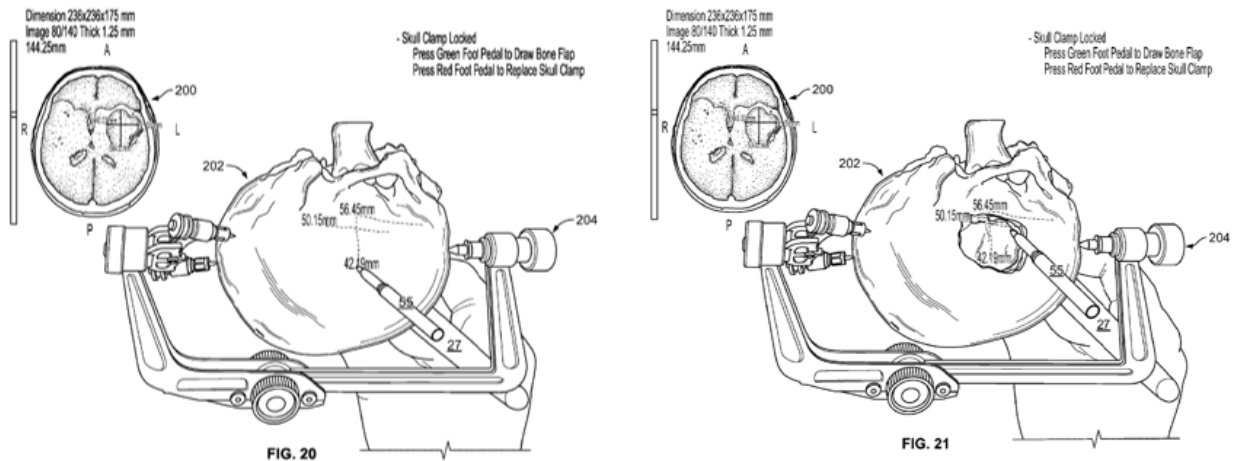


FIG. 2

143. Graphics rendering 46 generates a 3D stereoscopic image of the virtual tool at the updated position and orientation corresponding to stylus 27 for display on display 28 so that as the user manipulates the virtual tool via stylus 27 the virtual tool appears at the correct position and orientation. Banerjee, [0029], [0034]-[0035], [0042], [0044] (“With the models and other information, the graphics rendering software 46 [] generates and continuously updates, in real time, the stereoscopic 3D display that is displayed by [] display screen 28”).

144. Thus, each 3D stereoscopic image of the virtual tool at an updated position and orientation is “*a modified visual effect*” that is determined “*based in part on data received from the sensor*” as claimed—i.e., the appearance of the 3D image of the virtual tool is continuously modified based on the current position and orientation of stylus 27 received from haptic device 22, which is and/or includes [1D]’s “*sensor*” as I discussed in §VII.B.4 above. Banerjee, [0029], [0034], [0042]-[0044], [0053]-[0068].

145. For example, FIGS. 20 and 21 below show the “*modified visual effect*” of virtual marker 55 appearing differently as user 12 uses haptic stylus 27 to “manipulate the co-located virtual marker 55 to draw an outline of the intended craniotomy on the skin of the virtual patient head 202.” Banerjee, [0054].



146. Additionally, [1D1] is performed each time a user selects a different virtual tool to perform a different step of a surgical procedure and the new virtual tool is co-located with the current position and orientation of stylus 27 and displayed to the user—i.e., when the new virtual tool replaces the prior virtual tool and is displayed to the user. Banerjee, [0042]-[0044]; [0057]-[0068].

147. Computer 32's processor (i.e., any of computer 32's processor implementations I discussed in §VII.B.5 above) thus performs [1D1] by executing haptics and graphics rendering software 44, 46. Banerjee, [0038], [0042]-[0044].

b. [1D2]: “determine a haptic effect based in part on data received from the sensor;”

148. In my opinion, a POSA would have understood that haptics rendering 44 performs [1D2] by determining a “force feedback” corresponding to computed contact between virtual anatomy and the virtual tool updated to correspond with haptic stylus 27's current position and orientation received from haptic device 22,

as shown by the portion of the real-time haptics update emphasized in **red** in FIG. 2 below. Banerjee, [0042], [0044].

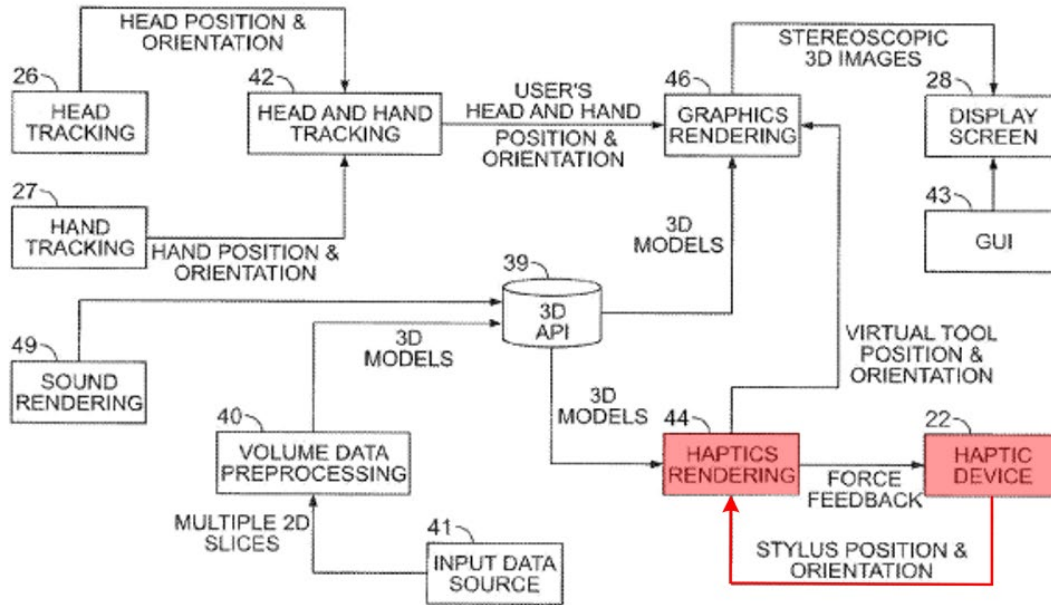


FIG. 2

149. Specifically, haptics rendering 44 (1) receives the current stylus position and orientation from haptic device 22 (which includes “*data received from the sensor*” as I discussed in §§VII.B.4 and VII.B.5.a above); (2) updates the position and orientation of the virtual tool to correspond to that of stylus 27; (3) computes “single or multi-point collisions” between the updated virtual tool and objects in the 3D virtual environment (e.g., virtual patient anatomy); and (4) determines the “force feedback” from “haptic materials” properties (e.g., “stiffness, viscosity, static friction and dynamic friction...density, mass, thickness, damping,

bending, etc.”) assigned to surfaces of the virtual objects contacted by the virtual tool. Banerjee, [0042].

150. Thus, by determining a force feedback based on contact between virtual patient anatomy and the virtual tool updated by the current position and orientation of haptic stylus received from haptic device 22, haptics rendering software 44 “*determine[s] a haptic effect based in part on data received from the sensor*” as claimed. Banerjee, [0042], [0044], [0057]-[0068].

151. Numerous examples of haptic rendering 44 performing [1D2] are provided in connection with haptic effects calculated for interactions between virtual patient anatomy and various virtual tools used in a simulated aneurysm procedure illustrated in Figure 5, annotated below with **red**-shaded ovals corresponding to steps (1)-(4) above that meet [1D2].

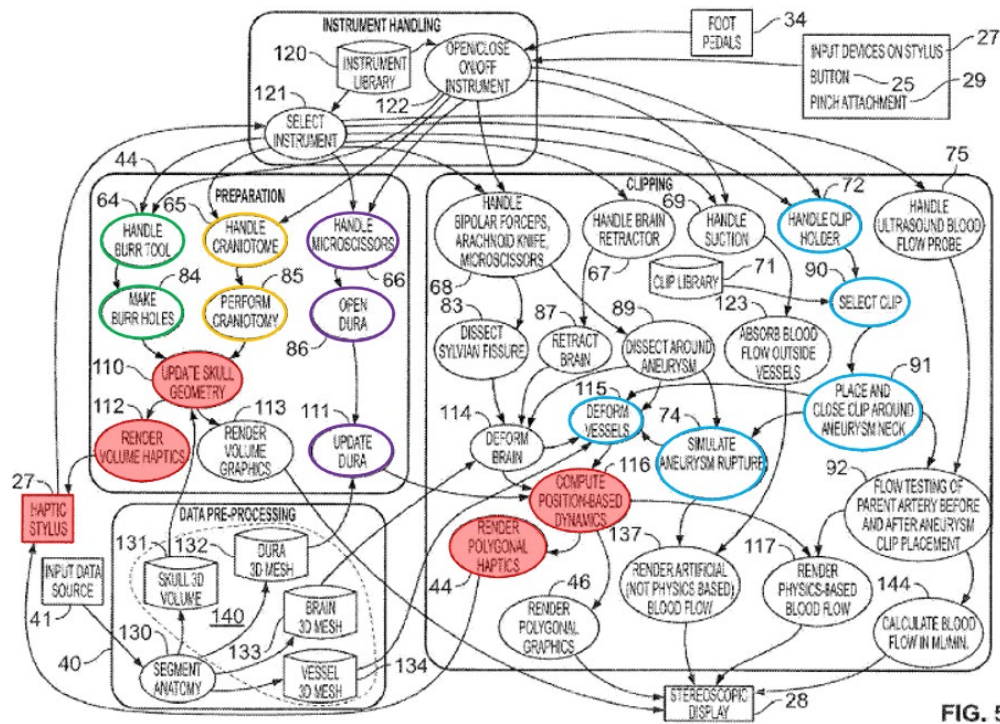


FIG. 5

152. For example, in simulating a brain dura cutting procedure (steps 66, 86 and 111 outlined in **purple**), “[b]ased upon position-based dynamics” (step 116 shaded **red**), “haptics rendering module 44 calculates the force that the user is exerting on the tool [virtual microscissors 57 illustrated in FIG. 18] to progressively cut the dura” (step 44 shaded **red**) and “outputs the force result to the haptic stylus 27.” Banerjee, [0059].

153. In an aneurysm clipping procedure (steps 72, 90, 91, 74 and 115 outlined in **blue**), haptics rendering module 44 “calculates the force that the user is exerting on the virtual clip holder 72 (FIG. 8) to deform the blood vessel and aneurysm, and outputs the force result to the haptic stylus.” Banerjee, [0066].

154. For a burr-hole drilling procedure (steps 64 and 84 outlined in **green**) using a burr tool 64 (Figure 11) and a craniotomy procedure (steps 65 and 85 outlined in **orange**) using craniotome 73 (Figure 9), haptics rendering 44 computes the force feedback of “drilling” and “sawing” respectively (step 112 shaded **red**) and outputs the force result to haptic stylus 27. Banerjee, [0057]-[0058].

155. Thus, computer 32’s processor (see §VII.B.5 above) performs [1D2] when haptics rendering software 44 determines any of these haptic effects based on the current position/orientation of stylus 27 output from haptic device 22. Banerjee, [0038], [0042]-[0044], [0057]-[0068].

c. **[1D3]: “transmit a display signal associated with the modified visual effect to the display, the modified visual effect to be displayed on the proxy object via the display;”**

156. In my opinion, a POSA would have understood that graphics rendering software 46 performs [1D3] each time it sends an updated image of the virtual tool to display screen 28.

157. As I discussed above in §VII.B.5.a, graphics rendering 46 determines [1D1]’s “*modified visual effect*” each time it generates an updated 3D stereoscopic image of the virtual tool. As shown by the portion of the graphic update path emphasized in **blue** in FIG. 2 below, computer 32’s processor performs [1D3] when graphic rendering 46 transmits the generated 3D stereoscopic image to display screen 28 for display. Banerjee, [0042]-[0044].

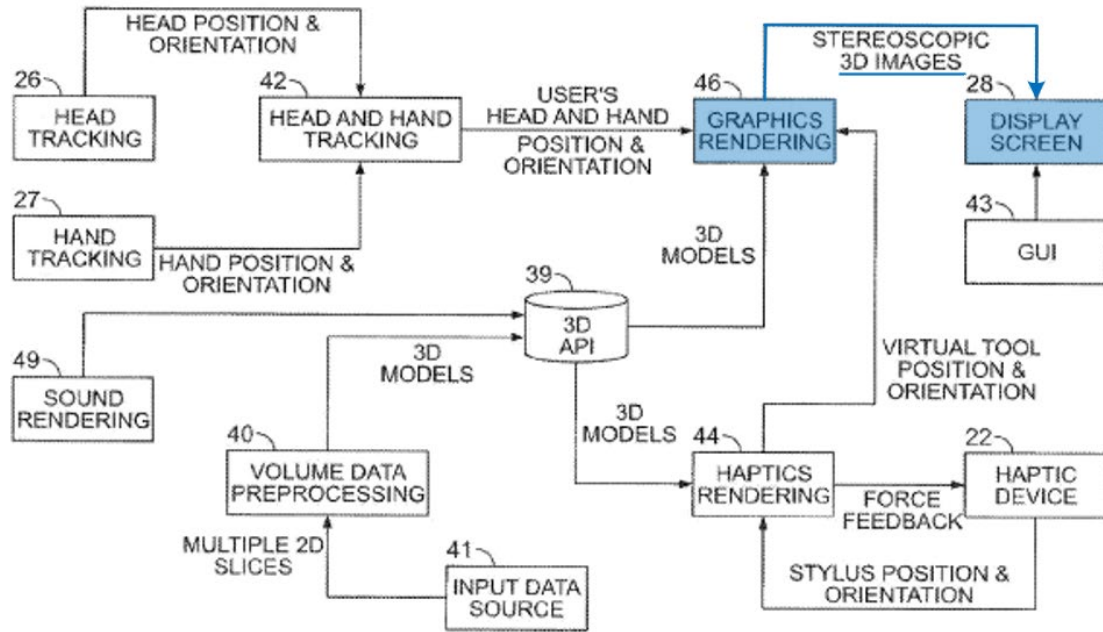


FIG. 2

158. A POSA would have understood that graphics rendering 46 “continuously updates” the stereographic 3D display on display screen 28 ([0044]) by transmitting “a display signal” with updated “stereoscopic 3D images” (FIG. 2). That is, a POSA would have understood that computer 32’s “graphics logic that drives the display system” ([0038]-[0039]) does so by transmitting a display signal with the updated image information generated by haptics rendering software 44 to display screen 28 for display. This display signal is “associated with the modified visual effect” because it includes the updated image information of the virtual tool at the updated position and orientation. Banerjee, [0044], [0053]-[0068]; §VII.B.5.

159. The “modified visual effect” of the updated virtual tool is “displayed on the proxy object via the display” for the same reasons that I discussed above in

§VII.B.3. Specifically, Banerjee’s OSS 10 meets [1D3] because its AR display system “superimpose[s] an image of the tool over the real haptic stylus 27 visible through partially transparent mirror” ([0057]) such that “a user can see aspects of real reality in addition to the superimposed virtual reality aspects” ([0029]).

Banerjee, [0034]-[0035], [0044], [0053]-[0068], FIGS. 19-21.

160. OSS 10’s AR display also meets patent owner’s broader interpretation that encompasses both AR and virtual-only displays because OSS 10 displays the image of the updated virtual tool. For example, in reference to the below image, I understand patent owner to have alleged that [1D3] is met because “[t]he virtual hand is rendered differently as the controller moves” (EX1006, 10)—i.e., the display of the updated virtual hand meets [1D3] (note there is no display of the controller (the alleged “*proxy object*”), virtual or otherwise). EX1006, 4-10; §VI.



161. Additionally, MSS 11's display likewise meets [1D3] under patent owner's interpretation because the user sees the "*modified visual effect*" of the updated virtual tool via the display screen. Like the displays patent owner accuses, MSS 11 displays only virtual objects, including the virtual tool controlled by haptic stylus 27. Banerjee, [0030], [0042]-[0044]; EX1006, 5-10; §VI.

d. [1D4]: "transmit a haptic signal associated with the haptic effect to the one or more haptic output devices;"

162. In my opinion, a POSA would have understood that Banerjee's processor performs [1D4] when haptic rendering software 44 instructs haptic device 22 to generate the "force feedback" that produces the haptic effect determined from the computed contact between the virtual tool and objects in the 3D environment (see my discussion in §VII.B.5.b above), as shown by the portion of the haptics feedback path emphasized in **red** in FIG. 2 below. Banerjee, [0042]-[0044].

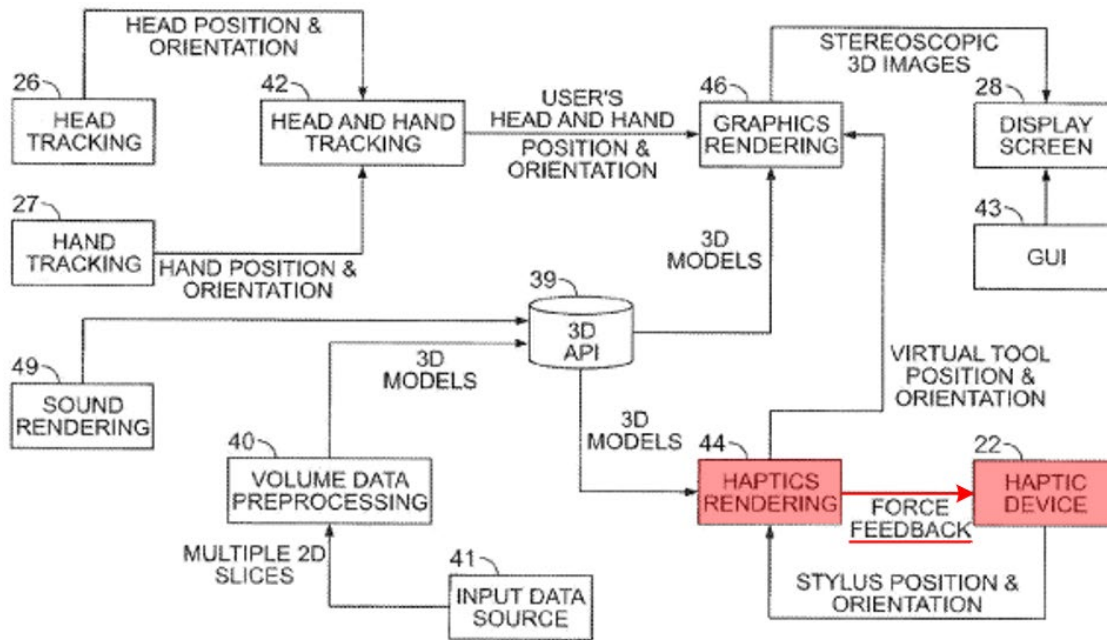


FIG. 2

163. Specifically, haptics rendering 44 “transmit[s] a haptic signal associated with the haptic effect” when it “direct[s] haptic device 22 to generate the corresponding force feedback” ([0042]) that produces the computed haptic effect felt by the user holding haptic stylus 27 (e.g., any of the haptic effects discussed in §VII.B.5.b above). Banerjee, [0042]-[0044], [0057]-[0068]. Thus, computer 32’s processor performs [1D4] by executing haptics rendering software 44.

e. **[1D5]: “output the haptic effect using the one or more haptic output devices.”**

164. In my opinion, a POSA would have understood that computer 32’s processor performs [1D5] by directing haptic device 22 to generate the computed force feedback haptic.

165. Directing haptic device 22 to generate the corresponding force feedback causes the user holding haptic stylus 27 to feel the corresponding “tactile sensations.” Banerjee, [0044]; §VII.B.5.d. Thus, haptics rendering software 44 is “*using*” haptic device 22 and its haptic stylus 27 to “*output the haptic effect*” as claimed—just like a computer prints a document using a printer, computer 32’s processor executing haptics rendering software 44 “drives each haptic device” to output the claimed haptic effect. Banerjee, [0038]-[0039], [0042]-[0044].

Alternatively, [1D5] is met by haptic device 22 (or its actuators) that outputs the force feedback via its stylus that haptics rendering 44 directed it to generate. Banerjee, [0044].

C. Claim 2: “The system of claim 1, further comprising a wearable device comprising one or more second haptic output devices.”

166. In my opinion, POSAs would have recognized the desirability of using a wearable haptic device such as a haptic glove as a second haptic device in Banerjee’s OSS 10 to provide haptic feedback to the user’s free hand interacting with the virtual scene, and that this obvious implementation meets claim 2.

167. Banerjee discloses that both OSS 10 and MSS 11 can employ multiple haptic devices 22. In Banerjee’s illustrated embodiments, haptic devices 22 are each implemented using a haptic robot stylus 27 that also implements Banerjee’s “hand tracking device” ([0032]-[0033]); one haptic device 22 for OSS 10 to

perform surgical steps with one tool, and two haptic devices 22 for the MSS 11 to perform surgical steps with two tools. Banerjee, [0032]-[0034], [0042]. Banerjee discloses that “[h]and tracking is very useful because it allows users to use both hands to interact with the virtual scene,” and notes that “[w]hile the user can feel tactile sensations with a hand holding a haptic stylus 27, it is also possible to use a tracked hand to move the 3D objects, manipulate lights” ([0044]).

168. This would most naturally and beneficially be implemented in OSS 10 by tracking the user’s free hand, for example, using an optical-based tracking system such as the “Leap Motion sensor” that Banerjee discloses as another available tracking mode. Banerjee, [0056] (OSS and MSS “may employ electromagnetic tracking, or other types of tracking, such as optical, inertial or physical tracking”); [0072] (the “illustrated apparatus shows one tracking mode combination” but “other tracking mode combination[s]” can be used for the “head and hand tracked system,” providing the “Leap Motion sensor” as an example).

169. Thus, Banerjee provides motivation to implement a hand tracked system for the user’s free hand (and discloses systems capable of doing so) to “move the 3D objects, manipulate lights” or otherwise “allow[] users to use both hands to interact with the virtual scene” ([0044]), e.g., to assist in performing OSS surgical steps where only one hand holds a virtual tool. Banerjee, [0044], [0072], [0052]-[0060], [0063]-[0068]; see also [0061]-[0062] (disclosing the user

switching to MSS 11 for procedures requiring the simultaneous use of two surgical tools).

170. Consistent with Banerjee's teaching to provide haptic feedback regarding the user's interaction with the virtual environment, it would have been obvious and desirable to provide haptic feedback corresponding to the user's free hand interaction with virtual objects using a well-known and conventionally used wearable haptic device such as a haptic glove. Examples of such conventional wearable haptic devices are disclosed in the references discussed below, including their use in providing haptic feedback in surgical simulations to interact with virtual patient anatomy.

- EX1012 (Meglan) discloses a hemorrhage control training simulator where a trainee interacts with a mannequin on which a virtual wound is overlaid, as discussed in detail in §VIII.A below. Meglan, [0059]. Meglan discloses the use of a haptic glove comprising a variety of haptic generators, e.g., pulse generators, heat generators, vibrators, coolers or "other haptic devices" ([0117]), worn by the trainee to allow the trainee to feel different characteristics of the virtual trauma victim the trainee is treating. Meglan, [0087]-[0088], [0105]-[0106], [0117]. Meglan's FIG. 7 below illustrates an example haptic glove worn by the trainee treating a virtual trauma.

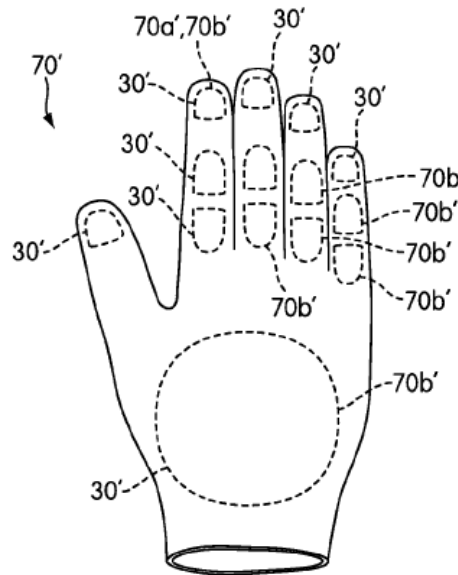


FIG. 7

- Meglan's system tracks the trainee's gloved hand as the trainee interacts with the virtual wound. Meglan, [0070]-[0073]. Thus, Meglan teaches the beneficial use of a haptic glove worn on a user tracked hand to allow a user to feel sensations of a virtual wound being treated that a POSA would recognize would benefit Banerjee's free-hand interaction with virtual anatomy.
- EX1008 also discloses the well-known use of a haptic glove in augmented reality to allow a user to feel virtual objects, here in the context of a driver of a vehicle. In EX1008, the system tracks an AR glove in a real-world space that appears to the driver to be occupied by a three-dimensional image of a control element of the vehicle (e.g., an infotainment system) via an AR headset. EX1008, Abstract,

[0021]-[0023], [0046]. The AR glove is used to provide “haptic feedback so that the driver feels the control element upon touching the space that appears to include the control element” (Abstract).

EX1008, [0021]-[0023]. The AR glove is a haptic glove that allows the user to “touch, grasp, and feel virtual objects as if they were real” ([0079]) via the AR glove’s haptic actuators, e.g., “one or more motors of the AR glove” ([0130]) so the user can feel the virtual control elements it is virtually controlling. EX1008, [0079]-[0085], [0124]-[0131], [0162]. Thus, EX1008 is another example of the known use of a haptic glove to allow a user’s tracked hand to interact with and feel the characteristics of virtual objects.

- EX1024 discloses the use of an input-output hand unit that can be implemented as “complete or partial glove-like unit” that provides “haptic output” (4:17-37) in a virtual reality surgical system so that the user can feel anatomical structures such as bone, muscles, organs, circulatory vessels, nerves, ligaments, tendons, connecting tissue, etc., thus providing another example of the known use of a haptic glove to provide the wearer with the sensations of touching virtual anatomical features. EX1024, 6:4-13, 7:23-31.

- EX1025 also discloses the use of a haptic glove in computer-assisted simulations of surgical simulations to allow the user to feel the mechanical reactions of virtual anatomical regions being operated on using hand tracking, thus providing another example of the known use of a haptic glove to provide a user with the feel characteristics of virtual anatomy. EX1025, 2:44-49, 5:1-14, 6:25-29.
- EX1026 notes that haptic gloves have “broad commercial applications, including in entertainment; medical and industrial training” ([0005]) and discloses a haptic feedback glove that can provide realistic touch sensations by using “multiple sensory modalities” ([0007]). An example of the haptic glove is illustrated below. EX1026, [0037], [0045]-[0049].

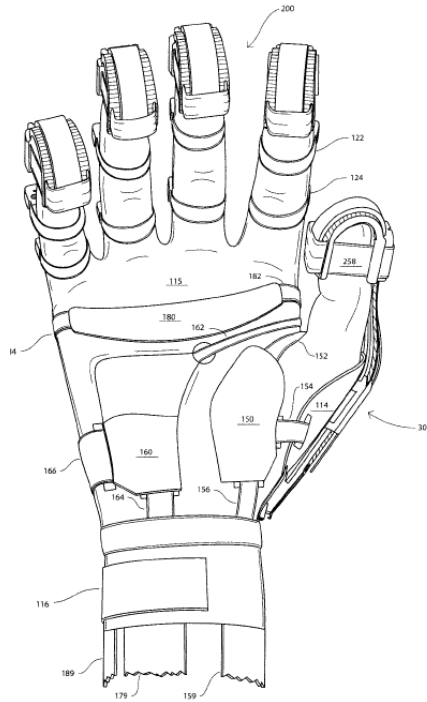


FIG. 1b

171. Thus, it was known to use haptic gloves to allow a user to interact with virtual objects and feel the characteristics of the virtual objects and POSAs would have recognized the benefit of implementing a second haptic device 22 using known wearable haptic devices in OSS 10 to “allow users to use both hands to interact with the virtual scene” that Banerjee teaches is “very useful” ([0044]) and employing a hand tracking device suitable for tracking the user’s free hand like the Leap Motion sensor or another optical tracking system that Banerjee says can be used. Banerjee, [0044], [0056], [0072]. Implementing a wearable haptic device in OSS 10 would have been no more than the obvious use of a known type of haptic device in the manner such haptic devices were conventionally used—i.e., to

provide haptic feedback corresponding to interaction with virtual objects—to provide the intended and predictable result of providing haptic feedback to a user’s free hand interacting with the virtual environment in Banerjee’s OSS 10.

172. POSAs would have had reasonable expectation of success because Banerjee’s haptics rendering software is already configured to receive location information from multiple hand-tracking devices (i.e., the illustrated haptic devices 22 implemented as a tracked haptic robot stylus) to compute corresponding haptic feedback ([0032]-[0034], [0042]-[0044]), and Banerjee discloses using hand-tracking modes suitable for free-hand tracking ([0056], [0072]). Thus, implementing known hand-tracking devices and providing calculated haptic feedback to a wearable haptic device would have required only conventional and routine skill.

173. This obvious and desirable use of a wearable haptic device worn on the user’s free hand meets “*a wearable device comprising one or more second haptic output devices,*” as claimed.

D. Claim 3: “The system of claim 1, wherein the proxy object comprises one or more of: a shoe, an article of clothing, an electronic device, a display, an interface object, or an interior of a vehicle.”

174. In my opinion, POSAs understood that haptic device and its component haptic stylus meet claim 3’s “*interface object*” and “*electronic device*” options for meeting the claim.

175. As I discussed above discussed in §VII.B.2.a, haptic device 22 with its haptic stylus 27 is an object that “provide[s] information regarding the user’s interaction with the system” ([0032]-[0033]) both to and from the simulation—i.e., haptic device 22 and haptic stylus 27 are each a claimed “*interface object*” because they each provide an interface with the user that collects the positional information that controls the virtual tool and by which interaction with virtual anatomy is computed, and provides the corresponding haptic feedback to the user. Banerjee, [0032]-[0044]. As also described above in §VII.B.2.a, haptic device 22 is an “*electronic device*” because its sensors and actuators are electrically powered. *See e.g.*, EX1017, 4:26-54 (describing “powered” rotary elements); EX1018, 5:54-6:28 (same), 5:29-33-36 (power connection “supplies electrical power to the interface 10 to operate internal components, including control circuitry, sensors, actuators and display elements); *see also* §VII.A.4.

E. Claim 4: “The system of claim 1, wherein the proxy object comprises neutral physical characteristics”

176. As FIGS. 6 and 19-21 of Banerjee show, haptic device 22’s stylus 27 has a neutral rod shape (see also FIG. 1 of EX1017 and FIG. 1A of EX1018) that can be made to look like any of many different virtual tools (e.g., the surgical tools illustrated in FIGS. 7-18) by superimposing their images on the neutral-shaped stylus. [0053]-[0054], [0057]-[0059], [0063], [0068]; §§VII.B.3, VII.B.5.a. Stylus 27 thus “*comprises neutral physical characteristics*” the same way the ’067 patent

describes—i.e., a proxy object with “neutral physical characteristics” needs a “visual overlay” to make it look a particular way. EX1001, 5:34-44.

F. Claim 5: “The system of claim 1, wherein the modified visual effect is configured to modify an appearance of the proxy object through the display.”

177. In my opinion, a POSA would have understood that Banerjee’s system meets claim 5 for the same reasons discussed above in §VII.B.5.a (see also §VII.B.5.c).VII.B.5.a

178. Specifically, OSS 10 meets claim 5 under both interpretations because the 3D image of a virtual tool (“*modified visual effect*”) is continuously updated to make haptic device 22’s haptic stylus 27 (both a “*proxy object*”) look like the virtual tool via the display in the manners I discussed above in §§VII.B.5.a, VII.B.5.c. *See also* §§VII.B.2.a-VII.B.2.b above where I discuss that both haptic device 22 and its haptic stylus 27 meet [1A]’s “*proxy object*.” MSS 11 additionally meets claim 5 under patent owner’s interpretation that encompasses AR and VR displays. §§VII.B.5.a, VII.B.5.c, VI; EX1006, 4-10.

G. Claim 6: “The system of claim 1, wherein the display comprises at least one of: a wearable device or a mobile device.”

179. In my opinion, a POSA would have understood Banerjee’s system meets claim 6 because OSS 10’s display system can be implemented using Microsoft Hololens (“*a wearable device*”) or, alternatively, because Banerjee

discloses its graphics user interface (GUI) 43 can be implemented by a tablet (“*a mobile device*”).

180. As I discussed above in §VII.B.3.a, OSS 10’s display system can be implemented using Microsoft Hololens ([0072]). Thus, in an OSS implementation using Microsoft Hololens, the display comprises the Hololens’s “head mounted display (HMD)” (EX1028, 1:12, 5:16-18)—i.e., a “*wearable device*.” EX1028, 2:25-26; 5:16-6:44.

181. Alternatively, Banerjee discloses that its “graphics user interface (GUI) 43” that allows a user to select the patient case to simulate “can be displayed on screen 48 and reflected on partially transparent mirror or displayed on an auxiliary tablet computer.” [0052]. Thus, Banerjee discloses an embodiment in which Banerjee’s display system also includes a tablet in addition to display screen 28/mirror 30 AR display. This display system meets [1A]’s “*display*”) and comprises “*a mobile device*” (i.e., Banerjee’s tablet computer) as claimed. EX1001, 3:60-61 (disclosing a tablet as an example of a mobile device).

H. Claim 7: “The system of claim 1, wherein the sensor comprises at least one of a camera, a laser, a radar, an accelerometer, a gyrometer, a pressure sensor, a magnetic sensor, a light sensor, a tracking sensor, or a microphone.”

182. In my opinion, a POSA would have understood that haptic device 22 meets at least claim 7’s “*tracking sensor*” and “*light sensor*” options.

183. As I discussed above in §VII.B.4, haptic device 22 “track[s] the user’s hand position and orientation” ([0034]) by tracking the position and orientation of its stylus 27 in real-time, and thus is or includes a “*tracking sensor*” as claimed. *See also* [0032] (OSS includes “a hand tracking device in the form of at least one haptic robot stylus”); [0033] (same for MSS).

184. That is, haptic device itself is a “*tracking sensor*” that a POSA would have understood includes multiple individual tracking sensors (e.g., optical encoders) that track the movement of haptic device 22’s articulating joints, as I discussed above in §§VII.A.4 and VII.B.4. An optical encoder is also “*a light sensor*” as claimed, and haptic device 22 meets claim 7 for this additional reason.

185. Banerjee also discloses that “[s]tandard image guided systems in the OR can employ an optical tracking system, whereas the open surgery simulator and/or microsurgery simulator may employ electromagnetic tracking, or other types of tracking, such as optical, inertial or physical tracking,” thus meeting claim 7 for additional reasons. Banerjee, [0056].

I. Claim 8: “The system of claim 1, wherein the processor is further configured to receive an input signal from an input capture device and determine the haptic effect based in part on data received from the input capture device.”

186. In my opinion, a POSA would have understood that computer 32’s processor meets claim 8 for multiple reasons discussed below.

187. First, FIG. 6 below shows a haptic stylus 27 that includes at least one “input device” including a “toggle button 25” (also referred to as “input device 25” ([0057]-[0059])) and/or “pinch attachment 29” that capture the user’s input of pressing or pinching them (i.e., “an input capture device”). Banerjee, [0051].

188. This input is received by haptic rendering 44 (i.e., “receive an input signal from an input capture device”) to control the operation of different virtual tools and to calculate corresponding haptic effects of the particular tool interacting with virtual patient anatomy (i.e., *determine the haptic effect based in part on data received from the input capture device*”), thus meeting claim 8. Banerjee, [0051], [0057]-[0059], [0063], [0065], [0068]; §VII.B.5.b.

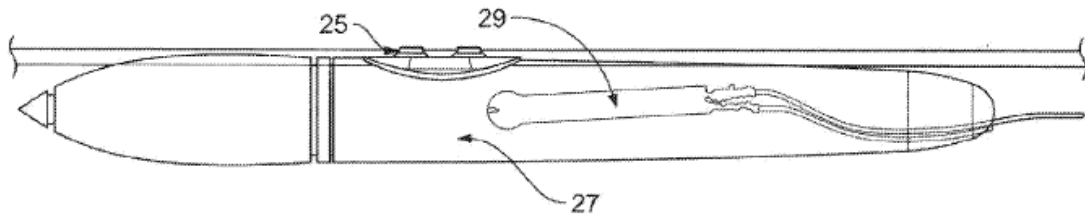


FIG. 6

189. For example, steps 122, 66, 86, 111, 116 and 44 shaded **purple** in annotated Figure 5 below meets claim 8 because the user “opens and close[s] the virtual microscissors by the haptic stylus **input device 25**” and “haptics rendering module 44 calculates the force that the user is exerting on the tool to progressively cut the dura and **outputs the force result to the haptic stylus 27**” ([0059])—i.e., the “input signal” indicating a button press is received by haptics rendering 44 and

used to “*determine the haptic effect based in part on data received from the input capture device.*” Banerjee, [0059].

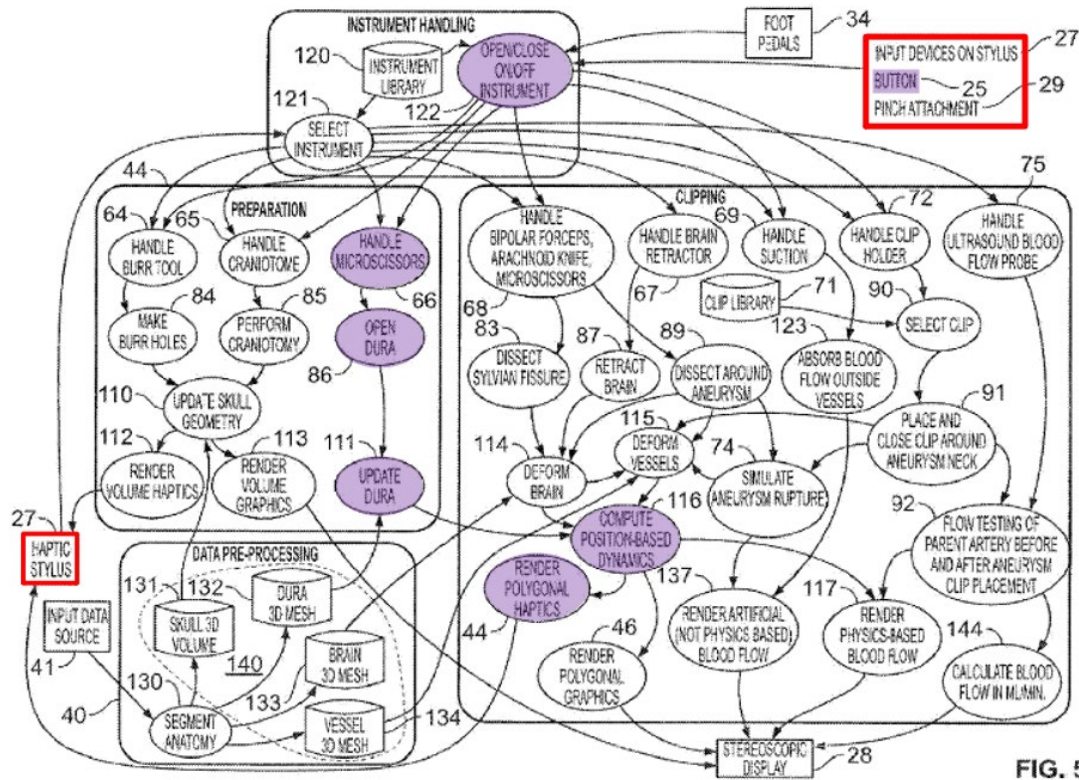
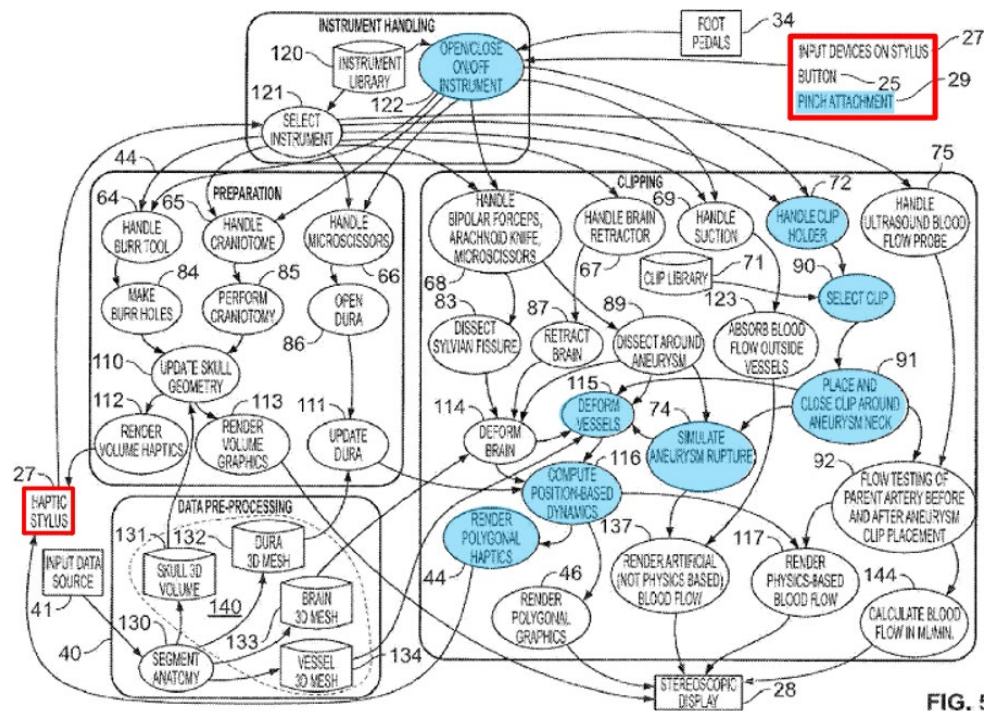


FIG. 5

190. Similarly, the steps 122, 72, 90, 91, 115, 116 and 44 shaded blue in annotated Figure 5 below also meet claim 8 because the user applies pressure to “pinch attachment 29” to manipulate “virtual clip holder 72” and haptics rendering 44 “calculates the force that the user is exerting on the virtual clip holder 72 (FIG. 8) to deform the blood vessel and aneurysm, and outputs the force result to the haptic stylus.” Banerjee, [0066]; *see also* [0057]-[0058] (describing “drilling” and “sawing” haptic effects of a burr tool and craniotome, respectively, activated using input device 25); §VII.B.5.b.



191. Therefore, computer 32 also meets claim 8 by executing haptic rendering software 44 that receives input from one or more input devices of stylus 27 to simulate a virtual tool. Banerjee, [0038], [0042]-[0044], [0051], [0057]-[0068].

192. Second, Banerjee also discloses a GUI (e.g., displayed on a tablet) via which the user selects a virtual tool. Banerjee, [0052]. Computer 32’s processor also meets claim 8 because haptics rendering software 44 will compute different haptic effects depending on the particular virtual tool (see §VII.B.5.b above discussing different haptic effects for different tools) that is selected by the user via the GUI displayed on the tablet—i.e., “*based in part on data received from the input capture device.*” This is analogous to the ’067 patent’s embodiment where a

“touch screen” is used as an “input capture device” through which the user can choose a texture. EX1001, 5:50-57.

193. Third, haptic device 22 itself is an “*input capture device*” because it captures the position/orientation of the user’s hand holding stylus 27 as input, and meets the rest of claim 8 for the reasons I discussed above in §VII.B.5.b.

J. Claim 11

194. Claim 11 recites the method that claim 1’s processor is configured to perform. Thus, Banerjee’s system meets claim 11 for the same reason it meets claim 1 that I discussed in §VII.B above, including each of claim 11’s method steps performed by computer 32 as I discussed in §§VII.B.5.a-VII.B.5.e above.

K. Claim 12

195. For the reasons I discussed above in §VII.C (Claim 2), it would have been obvious and desirable to implement a second haptic device 22 in OSS 10 as a wearable haptic device (e.g., a haptic glove) to provide haptic feedback to the user’s free hand interacting with the virtual environment, referred to hereinafter as Banerjee’s free-hand tracking implementation. Banerjee, [0044], [0072].

1. [12A]: “determining a second haptic effect;”

196. Claim 12 depends from claim 11 that Banerjee meets for the same reasons Banerjee meets claim 1 (see §VII.J discussed above). Thus, [11B]’s “*haptic effect*” (which is the same as [1D2]’s “*haptic effect*” discussed in §VII.B.5.b above) is a first haptic effect. As I discussed in §VII.C above, in

Banerjee's free hand-tracking implementation, the position/orientation information from a free-hand tracking device (e.g., an optical tracking system such as the Leap Motion sensor) is provided to haptic rendering software 44 that computes haptic feedback for interactions between the user's free hand and the virtual scene in the same way it does for interaction between a virtual tool and virtual patient anatomy. Banerjee, [0034] ("simultaneous use of two haptic devices 22"), [0042], FIG. 2.

197. Thus, Banerjee's free hand-tracking implementation "*determin[es] a second haptic effect*" when haptic rendering software 44 determines the force feedback corresponding to the interaction between the user's free hand and the virtual environment for a second haptic device 22 implemented as a haptic glove worn on the user's free hand.

2. [12B]: "transmitting a second haptic signal associated with the second haptic effect to one or more second haptic output devices;"

198. As discussed above in §VII.C, a POSA would have understood that haptic gloves provide haptic feedback via haptic actuators coupled to the portions of the glove worn by the user that are sensorized (e.g., fingertips, palm, etc.). *See, e.g.,* EX1012 (Meglan), [0087]-[0088], [0105]-[0106], [0117], FIG. 7; EX1026, [0037], [0045]-[0047], FIG. 1a, 1b; EX1008, [0130]. Banerjee's free-hand tracking implementation (§VII.C) thus performs [12B] when haptic rendering 44 directs one or more of haptic glove's actuators (i.e., "*one or more second haptic output*

devices”) to generate the force feedback computed from interactions between the user’s tracked free hand and the virtual scene (e.g., to move virtual objects in the scene, assist in surgical steps performed using a virtual tool held in the user’s other hand, etc. as discussed in §VII.C above) in the same way haptic rendering does for any haptic device 22. Banerjee, [0042], [0057]-[0068], FIGS. 2 and 5.

3. **[12C]: “outputting the second haptic effect using the one or more second haptic output devices, the one or more second haptic output devices being mechanically coupled to a wearable device.”**

199. Banerjee’s free-hand tracking implementation (§VII.C) performs [12C] when the actuators coupled to a haptic glove worn on the user’s free hand outputs the force feedback computed by haptic rendering 44. Banerjee, [0034], [0042], [0057]-[0068], FIGS. 2, 5.

- L. **Claim 15: “The method of claim 11, wherein the proxy object comprises one or more of: a shoe, an article of clothing, an electronic device, a display, an interface object, or an interior of a vehicle.”**

200. In my opinion, a POSA would have understood that Banerjee’s system meets claim 15 for the reasons I discussed above in §VII.D for claim 3’s identical limitations.

M. Claim 16: “The method of claim 11, wherein the proxy object comprises neutral physical characteristics.”

201. In my opinion, a POSA would have understood that Banerjee’s system meets claim 16 for the reasons I discussed above in §VII.E for claim 4’s identical limitations.

N. Claim 17: “The method of claim 11, wherein the modified visual effect is configured to modify an appearance of the proxy object through the display.”

202. In my opinion, a POSA would have understood that Banerjee’s system meets claim 17 for the reasons I discussed above in §VII.F for claim 5’s identical limitations.

O. Claim 18: “The method of claim 11, wherein the display comprises at least one of: a wearable device or a mobile device.”

203. In my opinion, a POSA would have understood that Banerjee’s system meets claim 18 for the reasons I discussed above in §VII.G for claim 6’s identical limitations.

P. Claim 19: “The method of claim 11, wherein the sensor comprises at least one of a camera, a laser, a radar, an accelerometer, a gyrometer, a pressure sensor, a magnetic sensor, a light sensor, a tracking sensor, or a microphone.”

204. In my opinion, a POSA would have understood that Banerjee’s system meets claim 19 for the reasons I discussed above in §VII.H for claim 7’s identical limitations.

Q. Claim 20: “The method of claim 11, further comprising receiving an input signal from an input capture device and determining the haptic effect based in part on data received from the input capture device.”

205. In my opinion, a POSA would have understood that Banerjee’s system meets claim 20 for the reasons I discussed above in §VII.I for claim 8’s identical limitations.

R. Claim 21

206. Claim 21 recites a non-transitory computer-readable memory with program code to cause a processor to perform the method of claim 11—i.e., the steps that claim 1’s processor is configured to perform. Banerjee’s computer 32 includes the software modules illustrated in FIG. 2, including haptics rendering software 44 and graphics rendering software 46, instrument library 120 illustrated in FIG. 5 that stores the virtual surgical instruments available to the user, and 3D API 39 that integrates the various software modules to provide the disclosed real-time simulations. [0037]-[0041], FIGS. 2, 5. A POSA would have understood that these software modules and libraries comprise program code that is stored on computer-readable memory that is non-volatile so that computer 32 can access the software and execute it to perform the disclosed simulations.

207. Thus, in my opinion, a POSA would have understood that computer 32 includes claim 21’s non-transitory computer-readable and computer 32’s

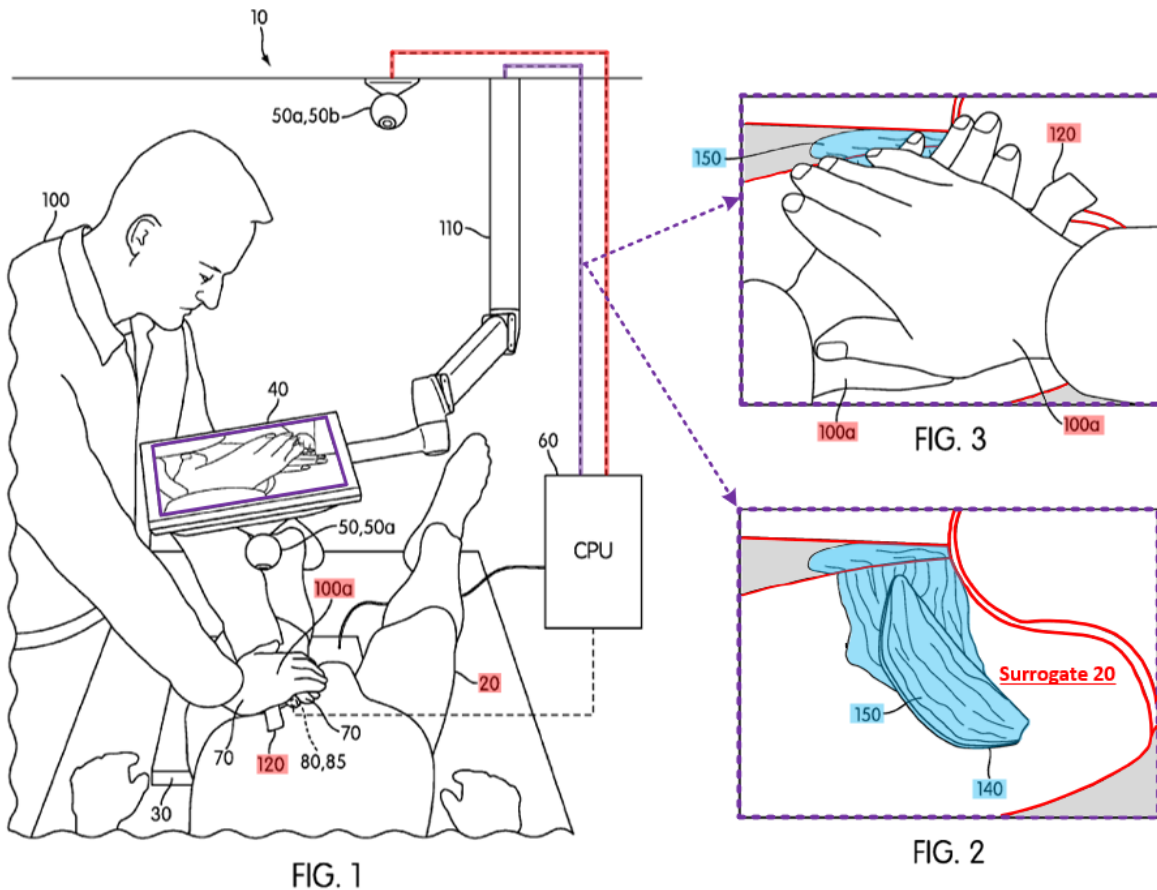
processor performs claim 21's steps for the same reason computer 32's processor performs the same steps in claim 1, as I discussed in §§VII.B.5.a-VII.B.5.e above.

VIII. GROUND 2: MEGLAN (CLAIMS 1-8, 11-12 AND 15-21)

208. I have been asked to provide my opinion concerning whether claims 1-8, 11-12 and 15-21 of the '067 patent are anticipated by Meglan or would have been obvious to a POSA in light of Meglan and the knowledge of a POSA. For the reasons explained below in §§VIII.B-VIII.R, it is my opinion that each of claims 1-8, 11-12 and 15-21 is anticipated by Meglan and/or would have been obvious to a POSA over Meglan. I understand that Meglan is prior art to the '067 patent based on Meglan's 2010-06-16 filing date and 2012-02-23 publication date.

A. Meglan (EX1012)

209. As I discussed above in §V.A.2.b, Meglan discloses an AR system using VST. In particular, Meglan describes a system that allows a user to practice controlling a hemorrhage by interacting with a physical mannequin with a simulated trauma "directly visually overlaid upon the mannequin anatomy" ([0059]) by merging a virtual trauma with the real-time video feed of the physical environment as shown in FIGS. 1-3 annotated below. Meglan, [0022], [0066]-[0072], [0082]-[0083].



210. As shown in Figure 1, simulator 10 comprises “video camera system 50” that acquires video of real objects in the environment (highlighted with **red**), including mannequin 20 used as a “physical surrogate” for a trauma victim. [0066]. To simulate a trauma, processor 60 merges the camera system’s video feed (also highlighted **red**) with computer-generated video of simulated wound 140 and hemorrhage 150 (shaded **blue** in Figures 2 and 3 above) and transmits the merged video feed (outlined in **purple** above) to display 40 so that trainee 100 sees the simulated trauma overlaid on surrogate 20 as shown in Figure 2’s snapshot before

trainee 100 has begun treating the wound. Meglan, [0066], [0069]-[0071], [0082]-[0084].

211. Processor 60 continuously updates the simulated trauma based on trainee 100's interaction so that the user sees his/her hands interacting with surrogate 20 (see Figure 3 above) and the "real time-impact on simulated wound 140 and blood flow 150" from those interactions as the trainee tries to stop the bleeding using different techniques. Meglan, [0082]. Haptic feedback can be provided so that trainee 100 can feel characteristics of the virtual trauma victim when interacting with the surrogate 20 (e.g., the patient's pulse, body heat, blood flow, shivering, etc.). Meglan, [0060], [0089]-[0090], [0106]-[0107], [0111], [0113], [0117].

212. In Figures 5 and 8 below, camera system 50 and display 40 are implemented via "head-mounted display 1010 (HMD)" with integrated "display 1040" and "video system 1050" ([0094]). In the Figure 8 embodiment, haptic feedback is provided via "sensorized substrate 2000" made of a flexible material that conforms to the shape of the surrogate 20 ([0107]-[0108]). Meglan, [0094]-[0117].

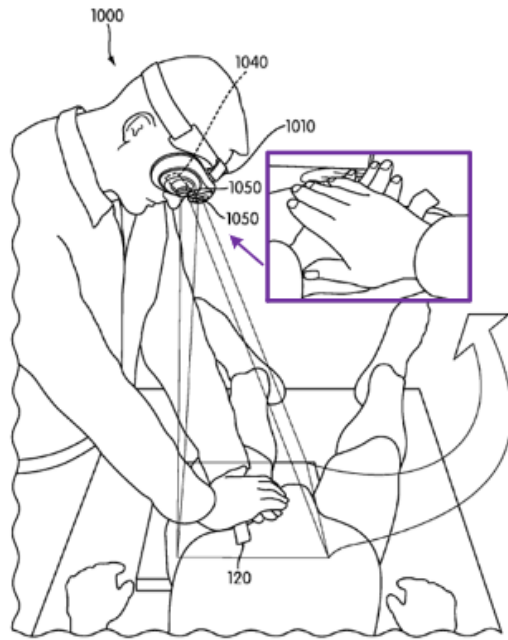


FIG. 5

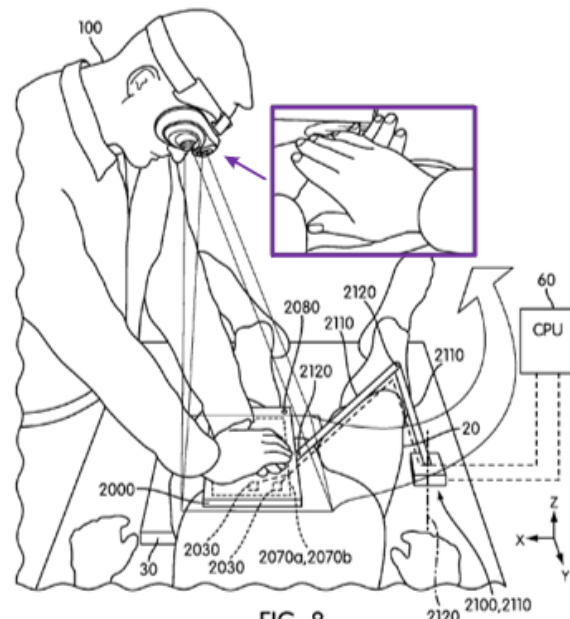


FIG. 8

B. Claim 1

1. [1PRE]: “A system comprising:”

213. In my opinion, a POSA would have understood that Meglan’s simulator meets [1PRE]’s “*system*” because it comprises components that function together and meet all of claim 1’s limitations (as demonstrated in §VIII.B.2-VIII.B.5 below). Meglan, [0070]-[0072], [0082]-[0084], [0094], [0107]-[0109].

2. [1A]: “a proxy object comprising one or more haptic output devices;”

214. In my opinion, a POSA would have understood that Meglan’s surrogate 20 and haptic substrate 2000 each on their own and together meet [1A] for the reasons discussed below.

215. Surrogate 20 is a “body mannequin” that “provides a physical representation of the anatomic area of a human body” that a trainee 100 interacts with to treat a virtual trauma. [0061]. As I discussed above in §V.B, a “surrogate” is another term for a “*proxy object*”—a real-world object used as a proxy for a virtual counterpart. Meglan, [0059], [0061], [0125] (describing different objects used as a “surrogate for another object”). Thus, Meglan’s surrogate 20 provides the “physical surrogate” ([0066]) for a simulated trauma victim and meets [1A]’s “*proxy object*.” [0062]-[0072].

216. Surrogate 20 also provides the anatomical interface between trainee 100 and the simulated trauma and is therefore an “interface object” that the ’067 patent gives as an example of a proxy object. EX1001, 5:34-37 (“proxy object 202 may take the form of any object, including...an interface object”).

217. Meglan’s FIG. 8 embodiment illustrated below uses “sensorized substrate 2000” (boxed in **red**) including “pulse generators 2070a” and “heat generators 2070b” to provide haptic output to trainee 100, so that the trainee feels characteristics of the virtual wound being treated (e.g., the victim’s pulse, the blood flowing from the wound, the heat of the victim’s body, etc.). Meglan, [0107], [0113], [0117].

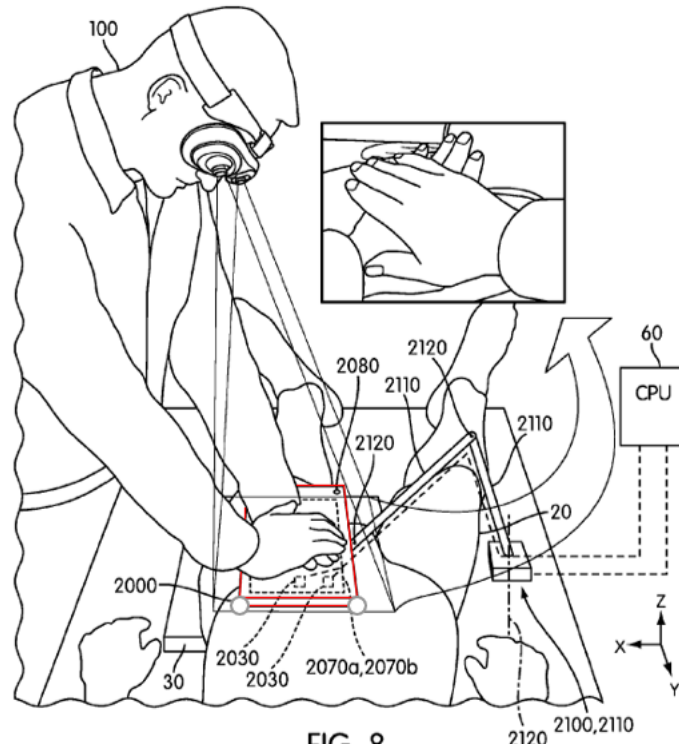


FIG. 8

218. As shown in FIG. 8 above, substrate 2000 is positioned in correspondence with the user's hands by device 2100 so that substrate 2000 is "sandwiched between the trainee's hands and the surrogate 20" such that when "trainee 100 attempts to contact the surrogate 20, the trainee 100 actually contacts the sensorized substrate 2000" ([0111]). Meglan, [0108]-[0110]. Substrate 2000 is made "flexible" so that "gravity causes it to generally conform to the underlying surface of surrogate 20." Meglan, [0109]. This "sheet-like" substrate formed of an "elastic material that has the feel of human skin" ([0114]) acts as a proxy for the skin of the anatomical region the trainee is treating and for the virtual wound for which the substrate provides haptic feedback. Substrate 2000 is thus also "*a proxy object.*" Indeed, Meglan discloses embodiments where "substrate 2000 is the

surrogate such that no *additional* surrogate (e.g., mannequin) is used” ([0118]), reinforcing that a POSA would have understood that substrate 2000 itself is “*a proxy object*.”

219. The “sensorized” substrate 2000 both provides the interface by which the simulator detects trainee 100’s interaction with the surrogate 20 and the interface through which haptic feedback is provided to the trainee. Meglan, [0107]-[0117]. Substrate 2000 is therefore both an “interface object” and “an electronic device” that the ’067 patent gives as examples of a proxy object. EX1001, 5:34-37 (“proxy object 202 may take the form of any object, including...an electronic device, [] or an interface object”).

220. Substrate 2000 is designed both to conform to surrogate 20’s surface so that the trainee can feel the underlying shape and mimic the mannequin’s skin feel so that the trainee perceives the substrate and the surrogate as the same object as if the trainee were interacting directly with surrogate 20, while simultaneously providing haptic feedback about characteristics of the virtual trauma victim and the wound (e.g., the victim’s pulse and body heat, the blood flow from the wound, etc.). Meglan, [0107]-[0111], [0113]-[0117]. Thus, a POSA would have understood that surrogate 20 and substrate 2000 together form a “*proxy object*” for a simulated trauma victim.

221. Both these proxy objects meet [1A] because substrate 2000 comprises “pulse generators” and “heat generators” that are “*haptic output devices*.” Meglan, [0107], [0111], [0113]; see also [0029], [0034], [0117] (disclosing that substrate 2000 may include “a vibrator” or a “cooler”); EX1001, 4:24-46.

222. Additionally, surrogate 20 itself meets [1A] because a POSA would have understood that surrogate 20 comprises the connected substrate that conformally contacts its surface. Meglan, [0108]-[0109], [0114]-[0115]. The '067 patent does not limit “*comprising*” to any particular relationship, nor does the patent describe or illustrate an example of a proxy object comprising one or more haptic devices. Instead, the '067 patent has a single sentence describing the FIG. 3 embodiment that reads “[w]earable peripheral device 304 and proxy object 302 comprise one more haptic output device(s) 118,” where proxy object 302 is illustrated as a circle with dashed lines as shown in FIG. 3 below (illustrated the same way in FIG. 2 and as a box in FIG. 4). EX1001, 6:26-29.

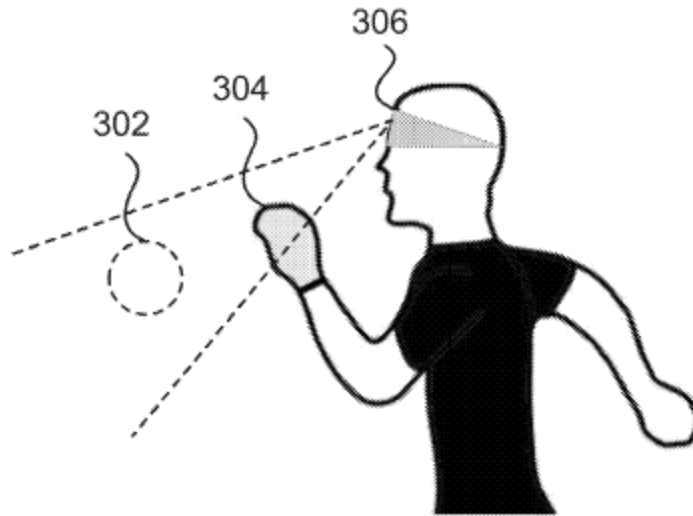


Figure 3

223. Thus, the '067 patent does not limit “*comprising*” to any particular relationship, let alone the relationship in Meglan where substrate 2000 is provided on and in contact with surrogate 20 to sensorize the portion of the surrogate that it covers. Meglan, [0108]-[0109], [0114]-[0115]. Thus, a POSA would have understood that surrogate 20 comprises substrate 2000 at least to the same extent the '067 patent’s embodiments do.

3. [1B]: “a display configured to output a visual effect onto a surface of the proxy object;”

224. Meglan’s simulator comprises a “display” implemented either as “a head mounted display equipped with a display(s)” for “an immersive experience” (e.g., HMD 1010 with integrated display 1040 in FIGs. 5 and 8) or as “a traditional computer monitor” (e.g., display 40 illustrated in FIG. 1). Meglan, [0059]; *see also*

[0070], [0094]. In my opinion, a POSA would have understood that both meet [1B].

225. As I discussed above in §VIII.A and as shown in annotated FIGS. 1 and 5 below, camera system 50/1050 captures real-time video of the physical objects in the environment (shaded **red**). Simulation program 90 (see FIG. 4) running on processor 60 “merges the input video feed” (outlined in **red**) from camera system 50/1050 with “simulated blood flow 150 and simulated wound 140” (i.e., “*a visual effect*”) and “provides this merged output video to the display” (as highlighted in **purple**). Meglan, [0082]; see also [0066], [0094].

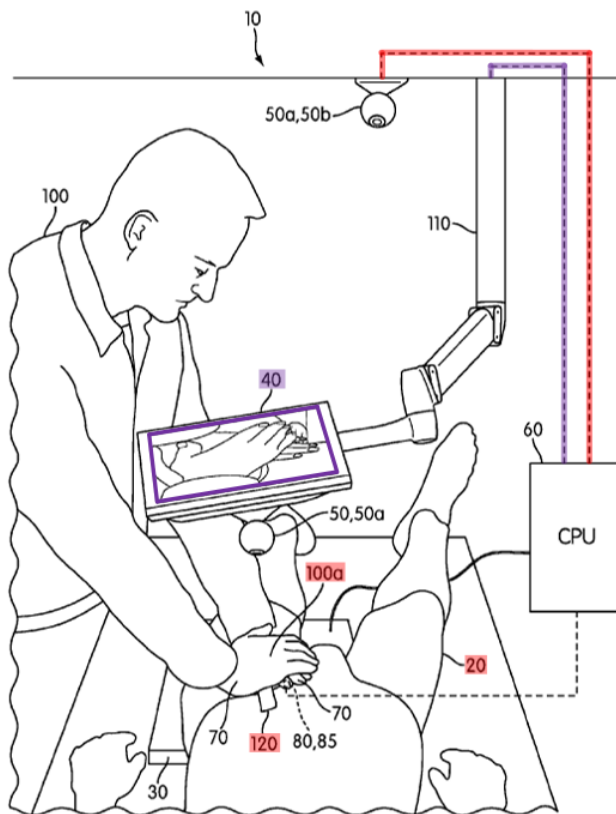


FIG. 1

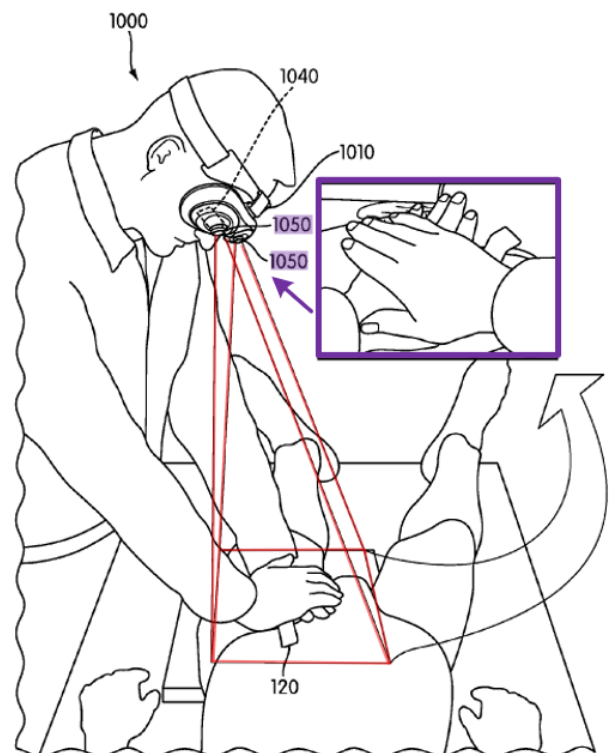


FIG. 5

226. As shown in the snapshots in FIG. 2 (before trainee begins treatment) and FIG. 3 (while trainee interacts with surrogate 20), the merged output video feed includes the “actual imaged objects” ([0084]) in the physical environment (indicated with **red**) with the simulated trauma overlaid on the surface of surrogate 20 and substrate 2000 “so that the real surrogate 20 is displayed with a simulated wound 140 and hemorrhaging blood 150” from the viewpoint of trainee 100. Meglan, [0066]; see also [0070]-[0072], [0082]-[0083].

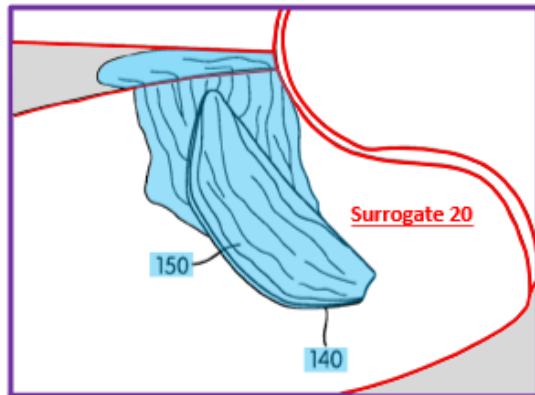


FIG. 2

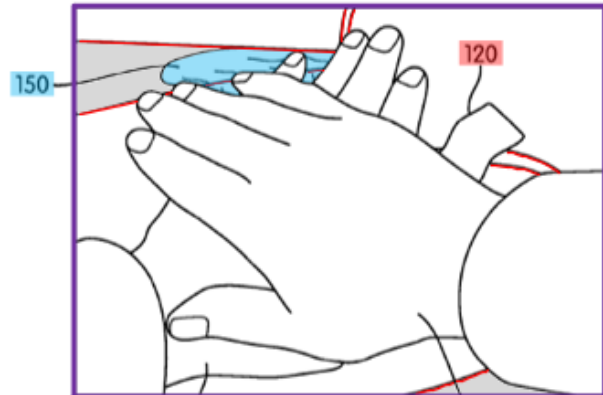


FIG. 3

227. Thus, display 40/1040 is “*configured to output a visual effect*” (i.e., the appearance of a virtual hemorrhaging wound) *onto a surface of the proxy object*” because the surface of the actual surrogate 20 and substrate in the real-world video gets overlaid with the virtual wound in the output video. Meglan, [0082]-[0084]. This also meets Immersion’s broader interpretation that encompasses both AR and VR displays for the reasons that I discussed in §§VI and

VII.B.3—i.e., Meglan’s display meets [1B] because it displays the virtual trauma simulation.

228. Meglan also discloses a VR display in which program 90 generates virtual re-creations of imaged objects so that the user sees only a simulated view consisting of virtual objects that meets [1B] under patent owner’s broad interpretation (see §VI above, EX1006, 4-5)—i.e., Meglan’s virtual-only display provides only computed-generated objects, including both the simulated trauma and virtual representations of the physical objects in the video feed of the real world. Meglan, [0084].

4. [1C]: “a sensor for tracking a position of the proxy object;”

229. In my opinion, a POSA would have understood that Meglan’s video camera system 50/1050 meets [1C] because its video feed is used to track the “position and orientation of objects viewed by the camera system.” Meglan, [0072]; *see also* [0073], [0094].

230. Specifically, camera system 50/1050 may include multiple cameras, each of which is “a sensor” as claimed (see, e.g., EX1001, 4:1-8, disclosing that cameras are sensors) to “provide stereoscopic information to triangulate the location of the imaged objects,” or may include “a single camera that includes distance sensors whose measurements are provided to processor 60 and program

90 to assist the program 90 in determining the position and orientation of the imaged objects.” Meglan, [0072]-[0073].

231. Thus, Meglan’s camera system 50/1050’s video stream from which program 90 detects in real-time the “three-dimensional shape and position and orientation of the surrogate 20, the trainee’s hands, and any other object[s]” (including substrate 2000, [0113]) to “track and identify their movements” ([0074]) meets [1C]’s “*a sensor for tracking a position of the proxy object.*” Meglan, [0070]-[0074], [0078]-[0079], [0081]-[0082].

5. [1D]: “a processor configured to:”

232. In my opinion, a POSA would have understood that Meglan’s “processor 60” meets [1D] because “simulation program 90” runs on processor 60 and “*configure[s]*” it to perform each of limitations [1D1]-[1D5] as demonstrated in §§VIII.B.5.a-VIII.B.5.e below. Meglan, [0070], [0103] (“processor 60 may comprise any suitable *processor* for running the simulation program 90”).

a. [1D1]: “determine a modified visual effect based in part on data received from the sensor;”

233. In my opinion, a POSA would have understood that Meglan’s processor 60 performs [1D1] when program 90 modifies the simulated trauma viewed by trainee 100 based on the video stream from camera system 50/1050, as illustrated in Figure 4 (annotated below).

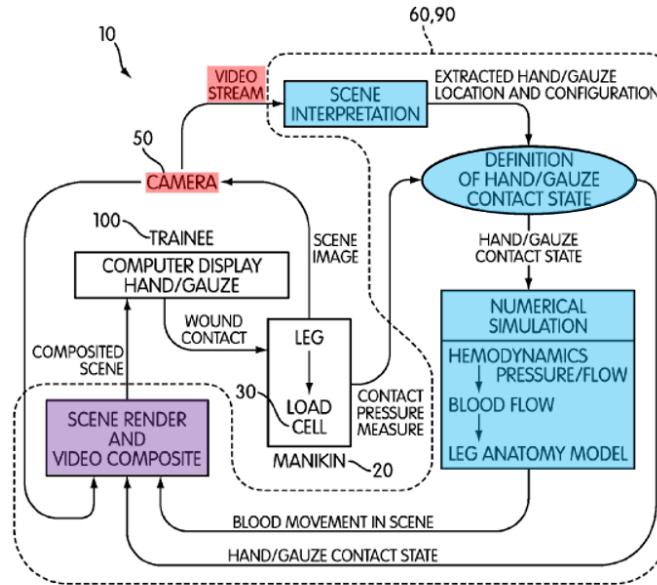


FIG. 4

234. Specifically, program 90 receives the video stream from camera system 50/1050 (as emphasized in **red**) (i.e., “*data received from the sensor*”) and determines how to update simulated wound 140 and hemorrhage 150 based on the current “three-dimensional shape and position and orientation of the surrogate 20, the trainee’s hands, and any other object that interacts with the surrogate” ([0074]), the trainee 100’s interaction with surrogate 20, and the characteristics of specific injury, illustrated by functionality emphasized in **blue**. Meglan, [0070]-[0082].

235. After updating the simulation, program 90 then generates “a video signal representative of the simulated wound 140 and blood flow 150” as it appears in the updated simulation state (highlighted in **purple**). Meglan, [0082]. Thus, program 90 performs [1D1] because the updated appearance of the hemorrhaging wound is “*a modified visual effect*” that program 90 determines in part from the

input video feed from camera system 50/1050—i.e., “*based in part on data received from the sensor.*” Meglan, [0072], [0074]-[0083]; [0094].

236. For example, FIG. 2 illustrates a “*modified visual effect*” of the simulated wound 40 on the leg of surrogate 20 determined from the position/orientation and shape of surrogate 20 detected from the video feed from the camera system. Meglan, [0072], [0074], [0078]. Specifically, program 90 “uses the geometry of surrogate” obtained from the video feed of the surrogate to “computationally calculate blood hemorrhage characteristics” ([0078]) of the simulation to modify the appearance of wound 40 and hemorrhage 50 over time. Meglan, [0070], [0074], [0078]-[0079], [0081]-[0082].

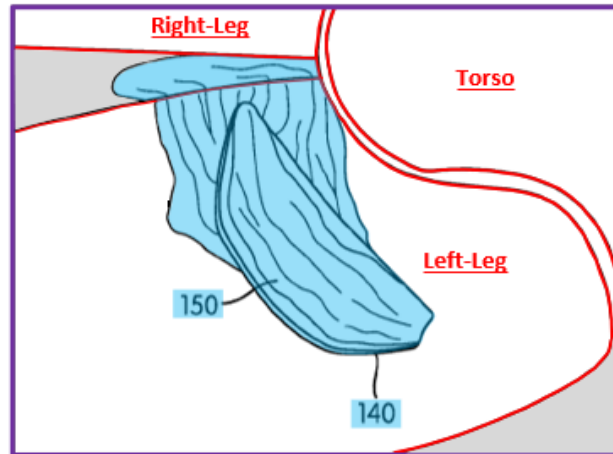


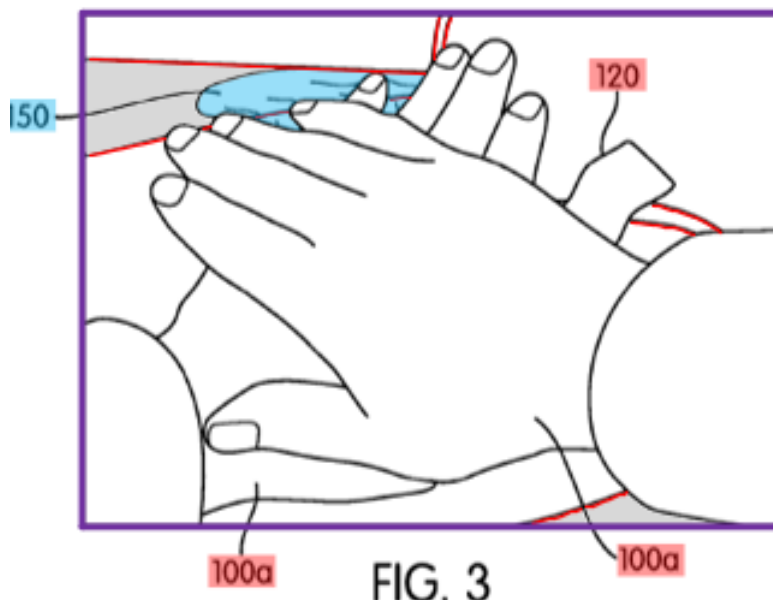
FIG. 2

237. At the instant of time captured in Figure 2, blood has flowed out of wound 140 along the contour of the leg and has begun to pool between surrogate 20’s legs. As the simulation progresses, program 90 performs the real-time update

discussed above, each of which produces the “*modified visual effect*” of the changed appearance of the simulated wound at a given instant in time based on the specific surrogate 20 geometry (shape, position, and orientation) detected from the video feed. Meglan, [0072]-[0074], [0078]-[0079], [0082].

238. When trainee 100 interacts with surrogate 20, program 90 determines further “*modified visual effect[s]*” from the input video feed such as detecting the position of the user’s hands and modifying the appearance of the simulated trauma so that it appears on the surface of surrogate 20 underneath trainee 100’s hands (as shown in FIG. 3 below), thus allowing trainee 100 to see the “real time-impact on the wound 140 and blood flow 150 of his/her interaction” with surrogate 20.

Meglan, [0082]; *see also* [0077], [0082], [0104].



239. Additionally, the appearance of the virtual wound is further modified when program 90 detects from the video feed that trainee 100's perspective has changed, either when the user repositions display 40 or a trainee wearing HMD 1010 "move[s] about the surrogate 20" and in response "updates the video signal outputted by the simulation in real time so that the view of the simulated wound 140 and blood hemorrhage 150 also follows the trainee's movements." Meglan, [0094]; *see also* [0065].

b. [1D2]: "determine a haptic effect based in part on data received from the sensor;"

240. In my opinion, a POSA would have understood that processor 60 performs [1D2] because program 90 determines multiple haptic effects based on the position of objects detected in the video feed from camera system 50/1050.

241. Substrate 2000's pulse generators 2070a and heat generators 2070b are "operatively connected to processor 60" so that processor 60 can control their operation. Meglan, [0106]-[0107] (disclosing that substrate 2000's pulse/heat generators are operatively connected to processor 60 like glove 70's pulse/heat generators).

242. As one example of a haptic effect that meets [1D2], when program 90 determines that trainee 100's hands are in contact with surrogate 20, program 90 uses "the location of the finger(s) over simulated vascular structures, combined with the current state of the hemodynamic simulation" to "calculat[e] a simulated

pulse” that processor 60 signals the pulse generator(s) to generate. Meglan, [0090]; *see also* [0106]-[0107]. The “specific feel of the pulse” provided by the “calculated simulated pulse” is a “*haptic effect*” that program 90 determines by combining load sensor data based on “the finger location(s) ***detected by the camera system 50***” (i.e., “*based on data from the sensor*”) and the state of the simulation, thus meeting [1D2]. Meglan, [0090].

243. As another example, when program 90 determines that trainee 100’s hands are in contact with surrogate 20 based on the video feed from camera system 50/1050 (i.e., “*based on data from the sensor*”), program 90 causes the heat generator to generate heat “so that the trainee feels the heat of the simulated patient’s body and/or blood upon contact with the simulated patient and/or hemorrhaging blood.” Meglan, [0089]; *see also* [0106]-[0107]; EX1001, 4:39-43 (using heating/cooling transducers to provide “thermal” haptic effects).

244. Both haptic effects are determined based at least in part on detecting the location(s) on surrogate 20 that the trainee’s hands are contacting from the video feed from camera system 50/1050, and therefore each meet [1D2].

- c. **[1D3]: “transmit a display signal associated with the modified visual effect to the display, the modified visual effect to be displayed on the proxy object via the display;”**

245. In my opinion, a POSA would have understood that processor 60 performs [1D3] when it displays the composite video of the current state of the

simulated trauma with the real-time video feed of the physical environment.

Meglan, [0082].

246. Specifically, processor 60 performs [1D3] each time program 90 merges the updated “video signal representative of the simulated wound 140 and blood flow 150” (i.e., “*the modified visual effect*”—*supra* §VIII.B.5.a) with the camera system’s video feed and “provides this merged output video feed to the display 40” (highlighted **purple**). Meglan, [0082]; *see also* [0094]; §VIII.B.5.a. A POSA would have understood that the merged output video feed is “*a display signal*” that is “*associated with the modified visual effect*” because it incorporates the video signal of the current state of the trauma.

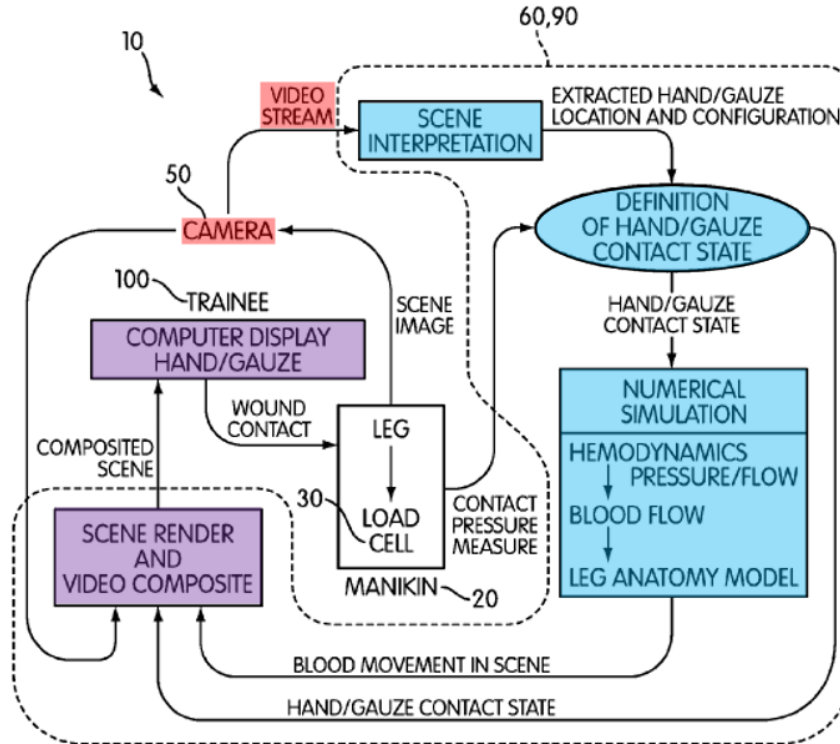


FIG. 4

247. The “*modified visual effect*” of the updated virtual wound/hemorrhage is “*displayed on the proxy object via the display*” by being “directly visually overlaid” ([0059]) on video of the actual surrogate 20 and substrate as I discussed above in §VIII.B.3 (also discussing that Meglan’s video overlay meets patent owner’s broader interpretation that also encompasses displaying only virtual content). Meglan, [0066], [0082]-[0084]. Meglan’s alternative virtual-only display where the program 90 generates the “entire video feed to be presented via the display 40” additionally meets [1D3] under patent owner’s broader interpretation. Meglan, [0084]; §VI; EX1006, 4-10.

d. [1D4]: “transmit a haptic signal associated with the haptic effect to the one or more haptic output devices;”

248. As I discussed above in §VIII.B.5.b, substrate 2000’s haptic output generators “operatively connect to the processor 60” that causes the haptic output generators to generate haptic feedback ([0107]). Meglan, [0029], [0089]-[0090]. A POSA would have understood that this involves processor 60 transmitting a signal to the haptic generators, instructing them what haptic effect to generate.

249. Thus, processor 60 causing substrate 2000’s heat generator(s) to “generate heat so that the trainee feels the heat of the simulated patient’s body and/or blood” meets [1D4]. Meglan, [0089]. Likewise, processor 60 causing substrate 2000’s pulse generator(s) to generate the “calculated simulated pulse” to

provide the “specific feel of the pulse” to the trainee meets [1D4]. Meglan, [0090]; *see also* [0107].

e. [1D5]: “output the haptic effect using the one or more haptic output devices.”

250. In my opinion, a POSA would have understood that [1D5] is met for the same reason as [1D4], like I discussed in §VII.B.5.e above.

251. Specifically, processor 60 “*output[s] the haptic effect using the one or more haptic output devices*” by causing substrate 2000’s haptic generators that are operatively connected to and controlled by processor 60 to output any of the haptic effects determined by program 90 that I discussed above in §VIII.B.5.b in connection with [1D2]. Meglan, [0029], [0082], [0089]-[0090], [0107].

C. Claim 2: “The system of claim 1, further comprising a wearable device comprising one or more second haptic output devices.”

252. Meglan discloses implementing haptic feedback via glove 70 or substrate 2000, both of which comprise the haptic output generators that provide the disclosed haptic feedback to trainee 100. Meglan, [0087]-[0088], [0105]-[0107].

253. Meglan further discloses that multiple trainees can use the simulator together to treat a simulated trauma, by interacting either with the same surrogate or with different surrogates at different locations. Meglan, [0124]. Each trainee uses a different camera system and display “operatively connected to the centrally

run program 90” ([0123]), which is programmed to “aggregate the simulated interactions so that each trainee sees the other trainees’ actions (e.g., via video feed of the other trainee’s hands) and effects on the simulated patient” ([0124]).

254. A POSA would have understood that different trainees would use different disclosed haptic devices based on availability, preference, convenience and/or role, thus beneficially providing flexibility in multi-trainee simulations. Meglan, [0059] (describing flexibility of different camera/display systems). In Meglan’s FIG. 8 embodiment, for example, when a first trainee interacts with substrate 2000, a second trainee would be allowed to participate in the same location using Meglan’ haptic glove. Trainee(s) at other locations may use Meglan’s haptic glove due to preference and/or availability. As another example, POSAs knew it may be advantageous for a trainee applying compression to use one type of haptic device while a trainee applying a tourniquet uses a different type, whether local or remote.

255. Thus, multiple obvious and beneficial implementations of Meglan’s multi-trainee simulator would include both substrate 2000 used by a first trainee and gloves 70/70’ (with pulse generator(s) 70a’ and heat generators 70b’ as illustrated in FIG. 7 below) worn by another trainee, thus further comprising “*a wearable device comprising one or more second haptic output devices*” as claimed. Meglan, [0088], [0106].

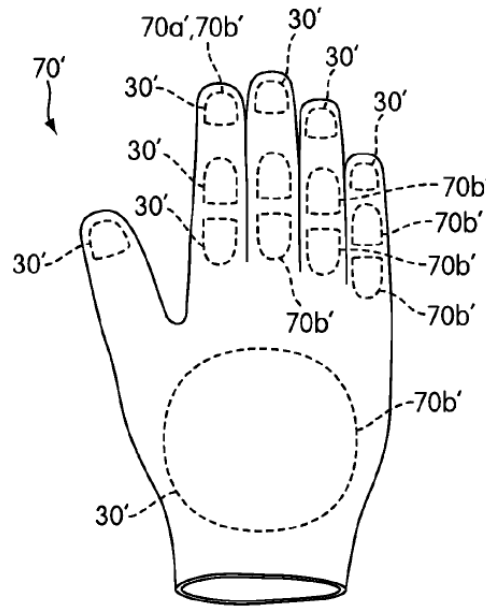


FIG. 7

256. POSAs would have had a reasonable expectation of success because a multi-trainee simulator in which trainees use both a sensorized substrate and a haptic glove merely implements the two types of haptic devices that Meglan discloses.

D. Claim 3: “The system of claim 1, wherein the proxy object comprises one or more of: a shoe, an article of clothing, an electronic device, a display, an interface object, or an interior of a vehicle.”

257. As I discussed above in §VIII.B.2, surrogate 20 provides an anatomical interface between trainee 100 and the simulated trauma and is therefore “*an interface object*.” Meglan’s “sensorized” ([0107]) substrate 2000 provides both the interface by which the simulator detects trainee 100’s interaction with the

surrogate 20 and the interface that outputs haptic feedback and is thus both “*an interface object*” and “*an electronic device.*” Meglan, [0107]-[0111].

E. Claim 4: “The system of claim 1, wherein the proxy object comprises neutral physical characteristics.”

258. As shown in FIGS. 1, 5-8, Meglan’s surrogate 20 (and substrate 2000 conforming to it) has a generic, neutral anatomical shape (like conventional skin-colored, rubber training mannequins, [0059], [0061], [0114]) that can be made to look like a trauma victim with any of various types of wounds via an AR overlay simulation. Meglan, [0082]. Surrogate 20 thus “comprises neutral physical characteristics” the same way the ’067 patent describes. EX1001, 5:34-44 (describing proxy object with “neutral physical characteristics” as one requiring “visual overlay” to make it look a particular way).

F. Claim 5: “The system of claim 1, wherein the modified visual effect is configured to modify an appearance of the proxy object through the display.”

259. As I discussed above in §§VIII.B.3 and VIII.B.5.c, Meglan provides real-time composite video overlaying the simulated trauma on surrogate 20 so that surrogate 20 appears to have the virtual hemorrhaging wound 140/150. As the appearance of the simulated wound is modified in response to treatment by trainee 100, so is the appearance of surrogate 20 and its substrate 2000 seen via the display with the overlaid modified wound, meeting claim 5. Meglan, [0082]. The appearance of substrate 2000 is also modified by being filtered out when merging

the virtual wound with the video feed of the physical environment, thus also meeting claim 5.

G. Claim 6: “The system of claim 1, wherein the display comprises at least one of: a wearable device or a mobile device.”

260. Meglan’s head-mounted display 1010 comprising display 1040 worn by trainee 100 (see FIGS. 5 and 8) is “*a wearable device*” that meets claim 6. Meglan, [0094].

H. Claim 7: “The system of claim 1, wherein the sensor comprises at least one of a camera, a laser, a radar, an accelerometer, a gyrometer, a pressure sensor, a magnetic sensor, a light sensor, a tracking sensor, or a microphone.”

261. As I discussed in §VIII.B.4, Meglan’s camera system 50/1050 meets [1C]’s “*sensor*” and comprises at least one “*camera*” and thus also meets claim 7. Meglan, [0072], [0094].

I. Claim 8: “The system of claim 1, wherein the processor is further configured to receive an input signal from an input capture device and determine the haptic effect based in part on data received from the input capture device.”

262. In my opinion, a POSA would have understood that processor 60 meets claim 8 because it receives data from pressure sensors and program 90 uses that data to calculate haptic effects.

263. Meglan’s simulator comprises load sensor(s) positioned under the surrogate (load sensor 30, [0070]), provided by glove 70 (load sensors 30’, [0105]-[0106]) or integrated in or on substrate 2000 (load sensors 2030, [0107], [0111],

[0113]) and operatively connected to processor 60. Processor 60 receives data from the load sensors (i.e., “*input signal[s] from an input capture device*”) and program 90 uses the load sensor data to calculate a simulated pulse (i.e., “*determine the haptic effect*”) output by pulse generators to provide the “specific feel of the pulse” that “reflect[s] the strength of the trainee’s pressing into the surrogate 20.” [0090]; *see also* [0107], [0113], [0117]. Meglan also discloses that the pressure applied by the trainee detected by the pressure sensors is used as input to the hemorrhage models to determine the blood flow simulation in response to the trainee treating, which in turn determines in part the heat sensation that the trainee feels via the heat generators. Meglan, [0077]-[0079], [0089]-[0090]. Thus, Meglan meets claim 8 for this additional reason.

J. Claim 11

264. Claim 11 recites the method that claim 1’s processor is configured to perform. In my opinion, a POSA would have understood therefore that Meglan’s simulator comprising processor 60 executing simulation program 90 meets claim 11 for the same reason it meets claim 1, as I discussed above in §VIII.B.

K. Claim 12

265. As I discussed above in §VIII.C, POSAs would have recognized that an obvious and beneficial implementation of Meglan’s multi-trainee simulator

would have included one or more trainees interacting with a same or different surrogates using gloves 70/70.’

1. [12A]: “determining a second haptic effect;”

266. Meglan discloses that “program 90 can aggregate the simulated interactions” of multiple trainees. Meglan, [0124]. Thus, [11B]’s “*haptic effect*” determined for trainee 100’s interaction with surrogate 20 (see §VIII.B.5.b discussed above in connection with [1D2]’s same “*haptic effect*”) is a first haptic effect and program 90’s computation of a haptic effect (e.g., simulated pulse or heat sensation) corresponding to a second trainee’s interaction with a same or different surrogate meets “*determining a second haptic effect.*” Meglan, [0088]-[0090], [0106]-[0107].

2. [12B]: “transmitting a second haptic signal associated with the second haptic effect to one or more second haptic output devices;”

267. Similarly, a POSA would have understood that program 90 performs [12B] when it causes the haptic output generators of the haptic device used by the second trainee to produce haptic effects (e.g., transmitting a signal to cause heat generator(s) to produce heat, or to pulse generator(s) to generate the calculated simulated pulse, etc.)—i.e., in the same manner [1D4] and [11D2] are met for the first haptic device used by the first trainee as I discussed in §VIII.B.5.d. Meglan, [0088]-[0090], [0106]-[0107] .

3. **[12C]: “outputting the second haptic effect using the one or more second haptic output devices, the one or more second haptic output devices being mechanically coupled to a wearable device.”**

268. In my opinion, a POSA would have understood that when the second trainee uses gloves 70/70' to interact with the shared simulation, [12C] is met by processor 60 causing pulse generator(s) 70a' to generate the simulated pulsed and/or the heat generators 70b' to produce heat sensations of the body/blood computed from the detected contact between the trainee's hands wearing gloves 70/70' having these haptic output generators mechanically coupled thereto (see, e.g., Figure 7). Meglan, [0088]-[0090], [0106]-[0107]; §VIII.B.5.e.

- L. **Claim 15: “The method of claim 11, wherein the proxy object comprises one or more of: a shoe, an article of clothing, an electronic device, a display, an interface object, or an interior of a vehicle.”**

269. In my opinion, a POSA would have understood that Meglan meets claim 15 for the reasons I discussed in §VIII.D above for claim 3's identical limitations.

- M. **Claim 16: “The method of claim 11 wherein the proxy object comprises neutral physical characteristics.”**

270. In my opinion, a POSA would have understood that Meglan meets claim 16 for the reasons I discussed in §VIII.E above for claim 4's identical limitations.

- N. Claim 17: “The method of claim 11, wherein the modified visual effect is configured to modify an appearance of the proxy object through the display.”**

271. In my opinion, a POSA would have understood that Meglan meets claim 17 for the reasons I discussed in §VIII.F above for claim 5’s identical limitations.

- O. Claim 18: “The method of claim 11, wherein the display comprises at least one of: a wearable device or a mobile device.”**

272. In my opinion, a POSA would have understood that Meglan meets claim 18 for the reasons I discussed in §VIII.G above for claim 6’s identical limitations.

- P. Claim 19: “The method of claim 11, wherein the sensor comprises at least one of a camera, a laser, a radar, an accelerometer, a gyrometer, a pressure sensor, a magnetic sensor, a light sensor, a tracking sensor, or a microphone.”**

273. In my opinion, a POSA would have understood that Meglan meets claim 19 for the reasons I discussed in §VIII.H above for claim 7’s identical limitations.

- Q. Claim 20: “The method of claim 11, further comprising receiving an input signal from an input capture device and determining the haptic effect based in part on data received from the input capture device.”**

274. In my opinion, a POSA would have understood that Meglan meets claim 20 for the reasons I discussed in §VIII.I above for claim 8’s identical limitations.

R. Claim 21

275. Meglan’s simulation program 90 “may be in any suitable form,” including a “program on a hard drive, CD, DVD, network server” or any “machine-readable medium encoded with machine-executable instructions executable by processor 60.” Meglan, [0104]. A POSA would have understood that these are examples of “[a] *non-transitory computer-readable medium comprising program code.*” Program 90 causes processor 60 to perform [21A]-[21D], which are the same as the steps that the processor is configured to perform in claim 1 and the same as the method of claim 11, for the reasons demonstrated above in §§VIII.B, VIII.J.

IX. GROUND 3: ROGERS (CLAIMS 1-8, 11-12, 15-21)

276. I have been asked to provide my opinion concerning whether claims 1-8, 11-12, and 15-21 of the ’067 patent are anticipated by Rogers or would have been obvious to a POSA in light of Rogers and the knowledge of a POSA. For the reasons explained below §§IX.B-IX.R, it is my opinion that each of claims 1-8, 11-12, and 15-21 is anticipated by Rogers and/or would have been obvious to a POSA over Rogers. I understand that Rogers is prior art to the ’067 patent based on Roger’s 2016-09-30 filing date and 2017-12-14 publication date.

A. Rogers (EX1010)

277. Rogers discloses an interactive virtual reality environment such as one used in a videogame system. [0001]-[0007]. Figure 1 depicts an exemplary “system for interactive gameplay of a video game” ([0021]):

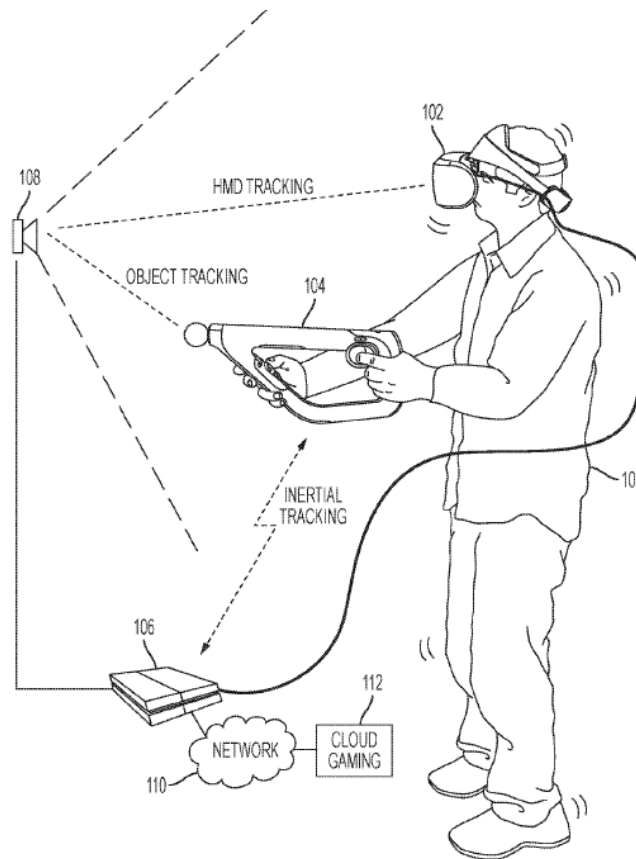


FIG. 1

278. In Rogers’s system, user 100 wears “a head-mounted display (HMD) 102...configured to display a video game or other content to the user” ([0042]) and holds “a directional interface object 104 to provide input for the video game” ([0044]). The system also includes a “computer 106” and a “camera 108” that “determine[s] the location and movements of the user 100, the HMD 102, and the

directional interface object 104.” Rogers, [0043]-[0044]; [0081]. Inertial sensors within interface object 104 are also used to detect its location. Rogers, [0044]; [0111]. Through HMD 102, user 100 sees a virtual video-game environment with a virtual weapon (e.g., a gun) in place of interface object 104 and a pair of virtual hands in place of the user’s own hands. Rogers, [0007], [0107]-[0109].

279. Interface object 104 also has touch sensors that detect how the user is holding the object, allowing the system “to properly render corresponding virtual hands in the VR environment.” Rogers, [0089]-[0096]. For example, by detecting which of the user’s hands (right or left) is holding the trigger area on interface object 104 and which hand is holding the front handle, the system can display the virtual hands the same way on the virtual gun. Rogers, [0054]-[0055]. This functionality is shown in Figures 10 (right-handed hold) and 11 (left-handed hold) below. Rogers, [0107]-[0109].

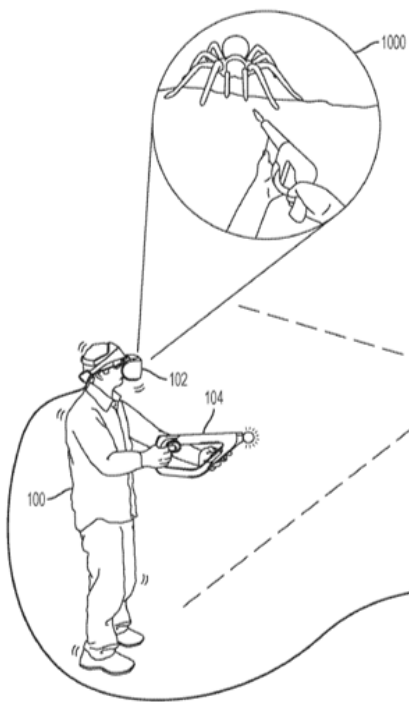


FIG. 10

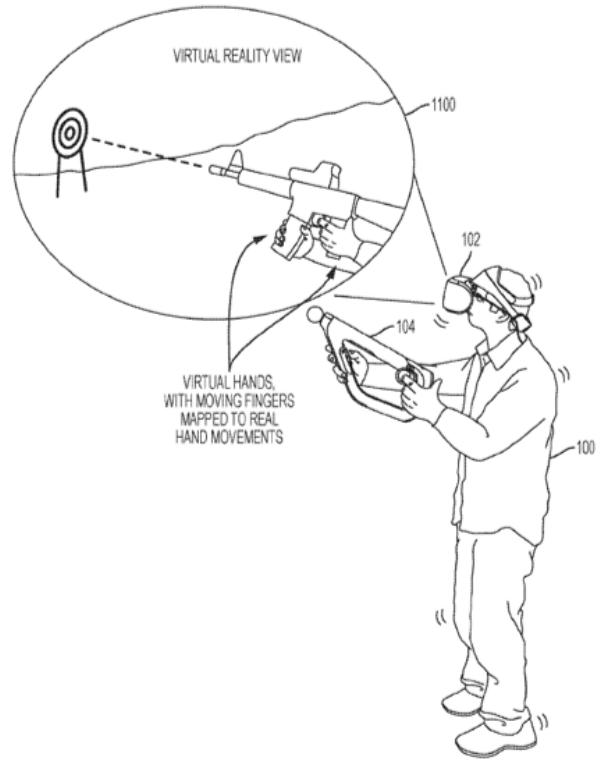


FIG. 11

280. Rogers further discloses using HMD 102 to provide an AR display to the user. Rogers, [0063]. As shown in FIG. 2A-2 below, HMD 102 includes video cameras 202A and 202B that capture images of the physical environment to provide “video see-through” so that the user can “see the environment external to the HMD 102 as if looking through the HMD 102.” Rogers, [0063]. Video from HMD 102’s video cameras “can be augmented with virtual elements to provide an augmented reality experience.” Rogers, [0063]. HMD 102’s video cameras may be positioned and oriented in any suitable manner to provide video of the physical environment. Rogers, [0063] (“it will be appreciated that there may be any number of externally facing cameras installed on the HMD 102, oriented in any direction”).

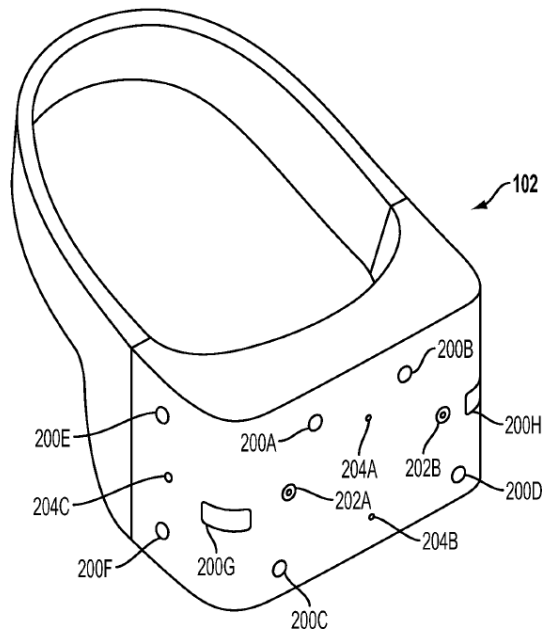


FIG. 2A-2

B. Claim 1

1. [1PRE]: “A system comprising:”

281. In my opinion, a POSA would have understood that Rogers’s “*system* for interactive gameplay of a video game” meets [1PRE]. Rogers, [0021]; *see also* [0018]; [0042]; claim 17; FIG. 1.

2. [1A]: “a proxy object comprising one or more haptic output devices;”

282. In my opinion, a POSA would have understood that Rogers’s interface object 104 meets [1A].

283. Interface object 104 is used “to provide input for the video game.” Rogers, [0044]. *See also* [0078]-[0096] (describing different features of interface object 104 that can be used to provide input during game play); FIGS 4A-4C, 5A,

12 (depicting same). In FIGs. 10 and 11 copied below, interface object 104 is used “to interact with the virtual scene” in which a “virtual weapon” corresponding to interface object 104 is displayed ([0107]). See also [0078]-[0096], [0108]-[0109].

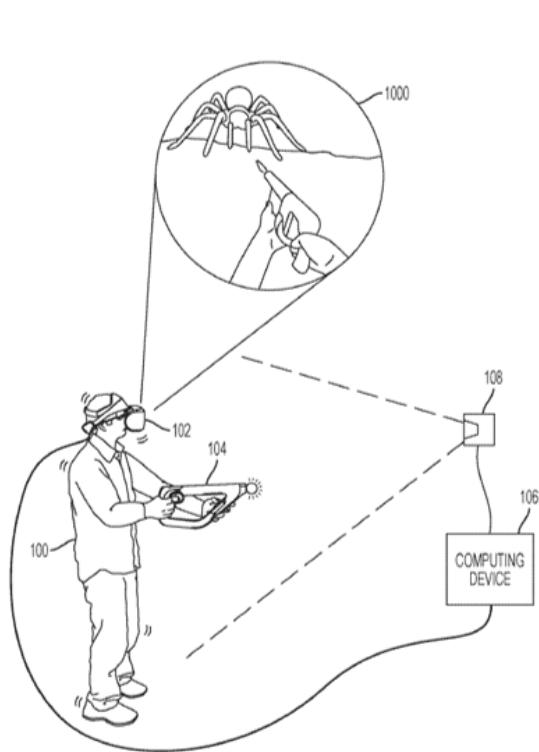


FIG. 10

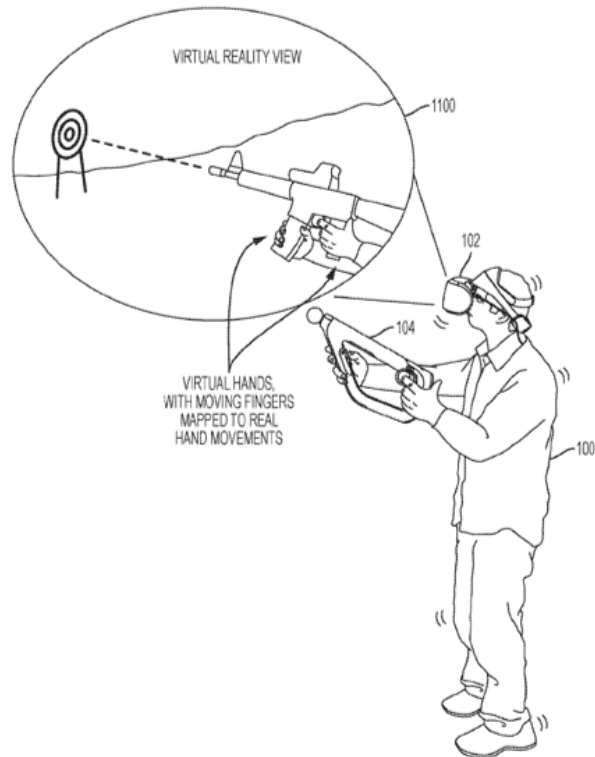


FIG. 11

284. The user controls the virtual weapon using interface object 104. Specifically, as the user moves interface object 104 being tracked by camera 108 and the inertial sensor(s), the virtual weapon displayed to the user moves in correspondence. Rogers, [0078]-[0096], [0107]-[0109]. The user can use interface object 104 in other ways to control the virtual weapon (e.g., a trigger on interface object can be pressed to “fire a virtual weapon” in a game, [0050]). *See also* [0059].

285. Thus, interface object 104 acts as a proxy for a “virtual weapon” counterpart in the virtual environment that is controlled by and moves in correspondence with the real-world interface object 104 and is therefore a “*proxy object*” as claimed. See §V.B above. As I also discussed in §V.B and in the previous grounds, the ’067 patent says that a proxy object “may take the form of *any* object,” including an “electronic device” and an “interface object.” EX1001, 5:34-38. **Interface** object 104 is both; it provides the interface that allows the user to interact with a virtual scene ([0043]-[0045], [0107]-[0109]) and it includes tactile feedback hardware that I discuss in the following paragraphs. Rogers, [0073], [0105], [0112].

286. Rogers discloses that interface object 104 includes “tactile feedback hardware” for rendering different “forms of tactile feedback” such as “vibration feedback, temperature feedback, pressure feedback, etc.” Rogers, [0073]; *see also* [0105], [0112] (“interface object 104 includes tactile feedback module 1224 for providing tactile feedback to the user...the tactile feedback module 1224 is capable of causing movement and/or vibration of the directional interface object 104 so as to provide tactile feedback to the user”), FIG. 12.

287. For example, “in response to tactile feedback data received from a computer,” interface object 104’s tactile feedback hardware can render “sensations of momentum” by controlling interface object 104’s “movable weight 800” (see

FIG. 8) at variable accelerations, velocities and distances to produce “a desired haptic effect...based on events occurring in the VR environment,” such as a “kickback sensation” when “the user fires a virtual weapon” or “mimic[ing] the sensation of weapon reloading mechanics” when the interface object is pointed upward. Rogers, [0105].

288. Interface object 104 comprises “*one or more haptic output devices*” at least because it comprises tactile feedback hardware including moveable weight 80 and the hardware that controls it to produce the desired haptic effect, thus meeting [1A].

3. [1B]: “a display configured to output a visual effect onto a surface of the proxy object;”

289. In my opinion, a POSA would have understood that Rogers’s head-mounted display (HMD) 102 meets [1B] at least under patent owner’s interpretation discussed above in §VI.

290. Rogers’s system includes “a head-mounted display (HMD) 102” that “is configured to display a video game or other content to the user 100” ([0042]). Rogers, [0060], [0070]; [0107]-[0109], [0119]-[0131]. Rogers’s head-mounted display is thus “*a display*,” as claimed.

291. In Figure 10 and 11 below, HMD 102 displays “a view 1000 of the VR environment” where “virtual hands” are displayed gripping a “virtual weapon” based on the user’s movement of interface object 104 and how the user is holding

it. [0044], [0052]-[0053], [0096]-[0097]; [0100]; [0107] (“the user is able to see corresponding virtual hands holding a virtual weapon that corresponds to the directional interface object 104”); [0109].

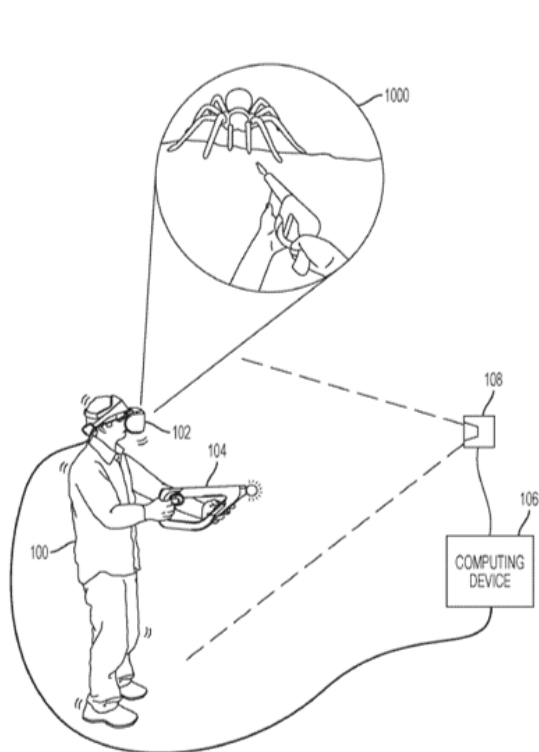


FIG. 10

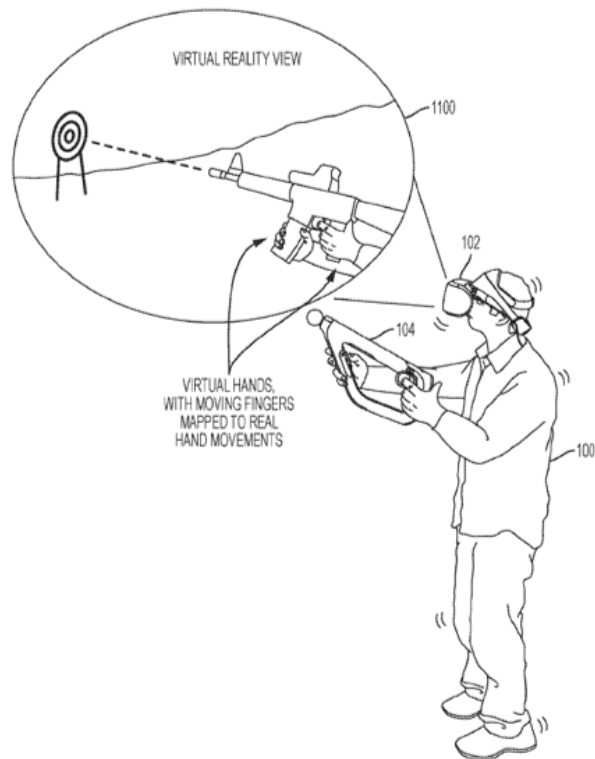
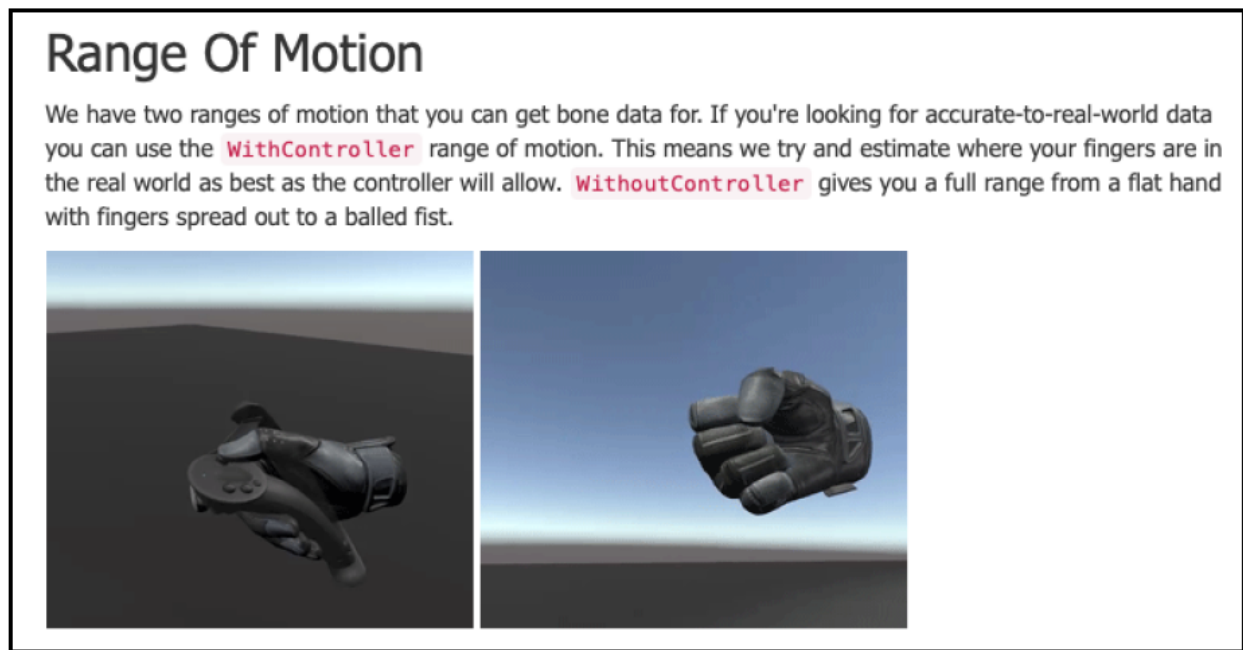


FIG. 11

292. As I discussed in §VI (Claim Interpretation) and in connection with [1B]’s “display” in Grounds 1 and 2 (§§VII.B.3, VIII.B.3), I understand the patent owner to contend in the district court litigation that a display is configured to “*output a visual effect onto a surface of the proxy object*” by displaying only virtual objects without any view of the physical environment. Specifically, I understand patent owner to allege that a videogame controller is the claimed “*proxy object*” (EX1006, 4) and that when a virtual reality headset displays a

virtual hand on a virtual representation of the videogame controller—not the real-world controller itself—the display is “*configured to output a visual effect onto a surface of the proxy object,*” as claimed.

293. That is, the patent owner contends that the below screen capture demonstrates that the alleged accused products meet [1B] by displaying virtual hands gripping a virtual controller (“WithController”) and even when virtual hands are displayed alone, i.e., without the virtual representation of the videogame controller being displayed (“WithoutController”). EX1006, 5.



294. Under patent owner’s interpretation of limitation [1B], Rogers’s HMD 102 is a “*a display configured to output a visual effect onto a surface of the proxy object*” at least because for FIGS. 10 and 11’s virtual reality view, HMD 102 displays virtual hands holding a virtual weapon (i.e., a “VR representation of the

directional interface object 104,” [0108]). Rogers, [0107]-[0109], FIGS. 10, 11. I note that patent owner also cited “virtual hand and sword” or “virtual hand and weapons” as examples of displaying visual effects on a proxy object. EX1006, 13.

295. Additionally, in Rogers’s “video see-through” AR embodiment I discussed above in §IX.A, HMD 102 is configured to display the video of the physical environment captured by its video cameras “augmented with virtual elements.” Rogers, [0063]. A POSA would have understood that the captured video is “augmented” by overlaying the “virtual elements” on the captured video of the physical environment (which in Rogers includes interface object 104 held by the user) in the manner that video see-through is conventionally and routinely performed, as I discussed above in §§V.A.2.b (“Video AR Displays”) and VIII.B.3 discussing Meglan’s VST display (*see, e.g.*, EX1013, 362-364; Meglan (EX1012), [0059], [0082]-[0084], FIGS. 1-5.). Rogers, [0063], [0068]-[0071], FIGS. 2A-2, 3.

296. A POSA understood that in an AR implementation of a video game like that illustrated in FIGS. 10 and 11 where the user moves interface object 104 to control a virtual weapon displayed to the user, augmenting the captured video with virtual elements would include overlaying images of the virtual weapon (and optionally virtual hands as discussed in further detail below) on the surface of interface object 104 in the captured video of the environment so that the user sees

himself/herself holding the virtual weapon in the augmented video displayed by HMD 102. Rogers, [0018], [0043]-[0045], [0063], [0068]-[0071], [0106]-[0109].

297. That is, a POSA would have understood from Rogers's disclosure of using interface object 104 to control a virtual weapon that is displayed to the user that, in an AR implementation of game play like that illustrated in FIGS. 10 and 11, captured images of the environment would be augmented at least with images of the virtual weapon so that the user sees himself/herself holding the virtual weapon in the AR display. Rogers, [0043], [0063], [0068]-[0071], [0107]-[0109]. Augmenting the captured video in Rogers's AR embodiment with a virtual weapon would have alternatively been the obvious and conventional way to implement what Rogers discloses. A POSA would have further understood that the captured video could also be augmented with virtual hands holding the virtual weapon to provide a straightforward way to display the appearance of the user holding the virtual weapon without having to mask out regions in images of the virtual weapon corresponding to the user's hands so that the user's actual hands appear on top of the virtual weapon in the AR display. *See e.g.*, Meglan (EX1012), [0134] (describing the video processing used to make the user's actual hands appear on top of the virtual wound in the composite video), FIG. 10. A POSA would have had a reasonable expectation of success in implementing Rogers's AR display with an overlay of a virtual weapon (with or without virtual hands) as doing so would

have been accomplished by applying known VST techniques to the video captured by HMD 102's video cameras. *See e.g.*, EX1013, 362-364; Meglan (EX1012), [0059], [0082]-[0084], FIGS. 1-5.

298. In this AR implementation, HMD 102 displays augmented video in which images of a virtual weapon (with or without virtual hands) are overlaid on the surface of interface object 104 in the captured video of the environment.

Rogers, [0043]-[0045], [0063], [0068]-[0071], [0107]-[0109].

4. [1C]: “a sensor for tracking a position of the proxy object;”

299. In my opinion, a POSA would have understood that Rogers's camera 108 and inertial sensors both meet [1C].

300. As seen in FIG. 1 below (“Object Tracking”), Rogers's system includes “a camera 108” that is used to “determine the location and movements” of interface object 104 from “capture[d] images of the interactive environment in which the user 100 is located” ([0044]). *See also* Rogers, [0053]-[0054], [0081] (describing a “trackable object 416” tracked by camera 108 “based on recognition in captured images of the interactive environment in which the directional interface object 104 is disposed.”); [0103] (describing “lights to facilitate tracking of the directional interface object”); FIGS. 4A-4C, 5A.

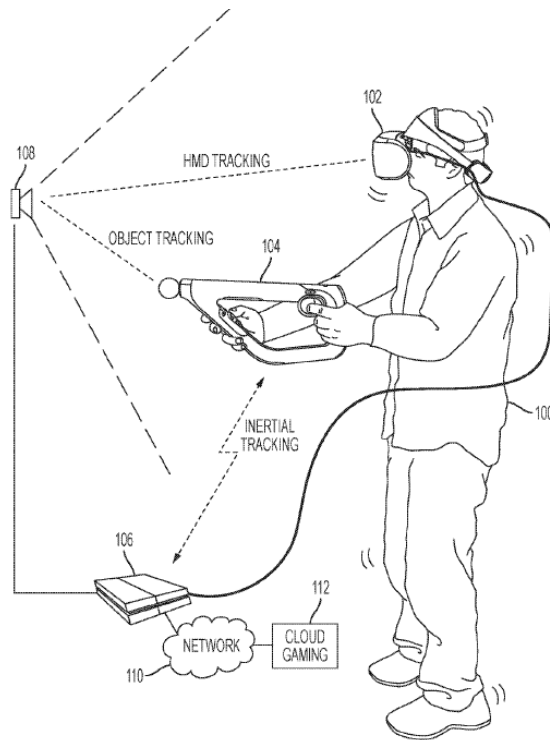


FIG. 1

301. Thus, camera 108's images are used to track "location and movement" of the interface object 104. Rogers, [0044]; see also [0053] ("tracking can be achieved by monitoring captured image frames of the scene in which user 100 is playing, which can detect the position of the HMD 102, and the directional interface object 104"). Camera 108 is thus "*a sensor for tracking a position of the proxy object,*" as claimed. EX1001, 4:1-8 (disclosing a "camera" as a type of "sensor[']").

302. Rogers's further discloses that the "directional interface object 104 includes an inertial sensor integrated therein, which allows for information regarding inertial tracking to be communicated with computer 106" ([0052]) to

determine interface object 104's "location and orientation" ([0044]). Rogers, [0044], [0052], [0111]; FIG. 1 (illustrating "Inertial Tracking" communicated between computer 106 and interface object 104); claim 9. FIG. 12's block diagram of interface object 104 shows this inertial tracking implemented by "[a] motion detection module 1208 [that] may include any of various kinds of motion sensitive hardware, such as a magnetometer 1210, an accelerometer 1212, and a gyroscope 1214." Rogers, [0111]; claim 9. Thus, interface object 104's inertial sensor is also "*a sensor for tracking a position of the proxy object,*" as claimed. EX1001, 4:1-18.

303. Consistent with the '067 patent's disclosure that "[a]ny suitable number, type, or arrangement of sensors can be used" and that "different embodiments may include cameras, lasers, radars, accelerometers, gyrometers, pressure sensors, magnetic sensors, light sensors, microphones, capacitive sensors, touch sensors, tracking sensors, or *any combination of such sensors,*" a POSA would have understood that camera 108 and interface object 104's inertial sensor together meet [1C]'s "*sensor*". EX1001, 4:1-18.

5. [1D]: "a processor configured to:"

304. In my opinion, a POSA would have understood that the processor within computer 106 meets [1D].

305. Rogers's system Rogers's system includes "computer 106" that can be "any general or special purpose computer known in the art," including a "gaming

console” or a “personal computer.” Rogers, [0043]; FIG. 1. Rogers explains that gaming consoles and personal computers, like computer 106, include “a processor” that can process “software stored on a computer readable medium.” Rogers, [0135]; [0003] (explaining a “game console is designed with specialized processing hardware, including a CPU,” i.e., a processor); *see also* [0153].

306. Rogers explains that “computer 106...execute[s] a video game.” [0043]. In Rogers’s system, “executing [a] video game is defined by a game engine 320.” Rogers, [0068]-[0070]; FIG. 3. POSAs would have understood a game engine includes a set of executable software instructions. In view of Rogers’s disclosures, POSAs would have understood that the processor within computer 106, e.g., its CPU, is what “executes” a video game in accordance with the game engine’s instructions because that is a conventional task a processor performs—e.g., just like Rogers says processor 1450 is “programmed with software instructions...to coordinate the various elements of Game System 1400” in Rogers’s server system implementation illustrated in FIG. 14. Rogers, [0147].

307. Thus, a POSA would have understood that computer 306 “execute[s] a video game, and output[s] the video and audio from the video game for rendering by the HMD 102” ([0043]) via its processor executing a gaming engine, an example of which is given by game engine 320 illustrated in FIG. 3, which Rogers says “define[s]” the video game ([0068]). *See also* Rogers, [0018] (disclosing that

Rogers’s system includes “a computing device” (e.g., a computer having a processor) “configured to execute an interactive application to render a view of a virtual environment to a head-mounted display (HMD), the computing device configured to process the captured images and the inertial data to determine a position of a virtual object that is rendered in the view of the virtual environment,” also recited in claim 17), [0068]-[0070] (describing FIG. 3’s video game engine).

308. Thus, computer 106’s processor is “*a processor*” as claimed, and is “*configured to*” perform limitations [1D1] to [1D5] when executing a video game as I discuss below in §§IX.B.5.a-IX.B.5.e with respect to these limitations.

a. [1D1]: “determine a modified visual effect based in part on data received from the sensor;”

309. In my opinion, a POSA would have understood that computer 106’s processor meets [1D1] because, in response to the user moving interface object 104, the processor modifies both the appearance of a virtual weapon corresponding to interface object 104 and the virtual hands that hold it.

310. As I explained in §IX.B.4 above in connection with [1C]’s “*sensor*,” computer 106 receives images from camera 108 and inertial tracking information from interface object 104’s inertial sensor to determine the “location and orientation” of interface object 104 ([0044]), shown as “Object Tracking” and “Inertial Tracking” in FIG. 1 below. *See also* Rogers, [0018], [0052] (“The directional interface object 104 includes an inertial sensor integrated therein, which

allows for information regarding inertial tracking to be communicated with computer 106.”), [0053] (“tracking can be achieved by monitoring captured image frames of the scene in which the user 100 is playing, which can detect the position of the HMD 102, and the directional interface object 104”), [0106].

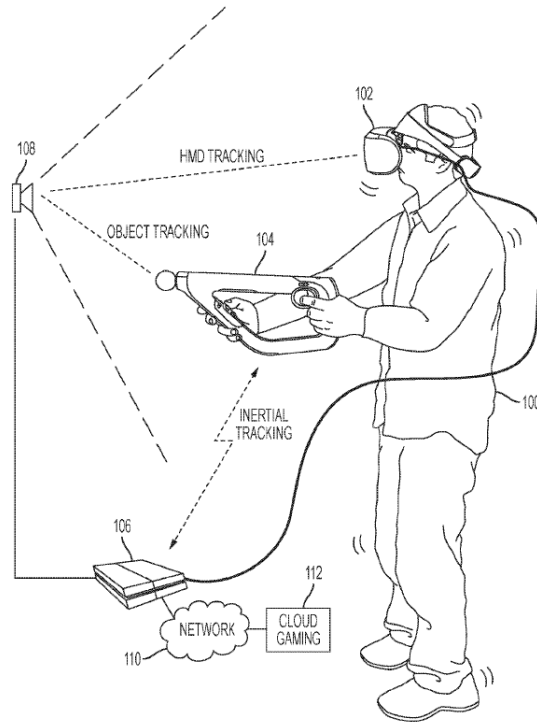
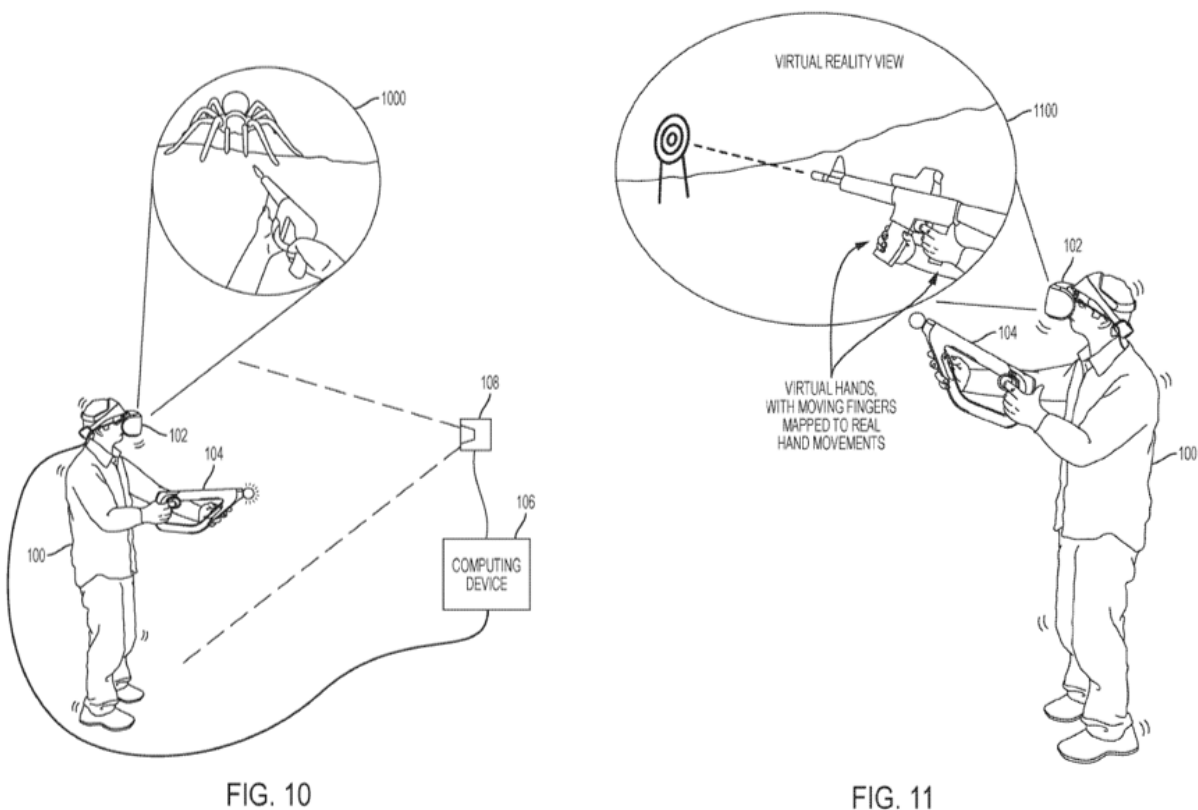


FIG. 1

311. Thus, as user 100 moves interface object 104 to control a virtual weapon (see, e.g., FIGS. 10-11 below) in a video game executed by computer 106 ([0043]) (e.g., by executing FIG. 3’s game engine), computer 106’s processor tracks movement of interface object 104 to determine its location and orientation based on camera 108’s images and inertial tracking information from interface object 104’s inertial sensor—i.e., “*based in part on data received from the sensor*”

because both camera 108 and interface object 104's inertial sensor, by themselves and together, meet [1C]'s "sensor," as I discussed in §IX.B.4 above. Rogers, [0044], [0052], [0055], [0106] ("A combination of visual tracking of the trackable object and data from inertial sensors in the directional interface object can be utilized as input to determine the pointing direction of the virtual weapon in the VR environment").



312. Computer 106's processor uses the tracked location and orientation of interface object 104 to render the video displayed on HMD 102 (see [0018], [0043], [0070]) so that the display of the virtual weapon and virtual hands holding it (i.e., "a modified visual effect") changes in correspondence with the detected

location and orientation of interface object 104—i.e., computer 106’s processor determines the “*modified visual effect*” that the user sees as virtual hands gripping a virtual weapon (see, e.g., FIGS. 10-11 above) that points in the same direction detected for interface object 104. See Rogers, [0018] (disclosing the computing device “execute[s] an interactive application to render a view of a virtual environment to a head-mounted display (HMD), [0043] (disclosing that computer 106 “execute[s] a video game, and output[s] the video and audio from the video game for rendering by the HMD 102”), [0044]-[0045] (using interface object 104 “it is possible to interface, control, maneuver, interact with, and participate in the virtual reality environment presented on the HMD 102”), [0052], [0055] (“Detecting the manner in which the user is holding the directional interface object 104 is used to provide a corresponding holding orientation of the virtual object in the virtual-reality scene viewed via the HMD 102”), [0068]-[0070] (gaming engine 320’s “video rendering module 322 is defined to render a video stream for presentation on the HMD 102.”), [0106]-[0109]; §IX.B.5 (explaining that a POSA would have understood that computer 106’s processor executes the game engine’s functionality because in the FIG. 1 embodiment computer 106 “execute[s] [the] video game,” [0043]).

313. Computer 106’s processor thus “*determine[s] a modified visual effect based in part on data received from the sensor*” because it modifies the appearance

of the virtual weapon and the virtual hands holding it in correspondence with the detected movement of interface object 104 held in the user's hands.

314. A POSA understood that computer 106's processor modifies images of virtual elements appearing in augmented video of the physical environment in Rogers's AR display in the same way that computer 106's processor modifies the images of virtual elements appearing in the video of a VR display based on the detected location and orientation of interface object 104. Rogers, [0018], [0043]-[0045], [0063], [0068]-[0071], [0106]-[0109]; FIG. 3. Thus, in Rogers's AR embodiment discussed above in §IX.B.3 ([1B]), computer 106's processor modifies the appearance of the virtual weapon (with or without virtual hands) in the augmented video to match the detected location and orientation of interface object 104.

b. [1D2]: “determine a haptic effect based in part on data received from the sensor;”

315. In my opinion, a POSA would have understood that computer 106's processor performs [1D2] when it determines tactile feedback data to cause interface object 104's moveable weight to produce desired haptic effects.

316. Rogers's game engine 320 executed by computer 106 in the FIG. 1 system (see [0043]-[0046] and §IX.B.5 above discussing [1D]'s “*processor*”) includes “tactile feedback module 326” that “is configured to provide signals to tactile feedback hardware included...interface object 104.” Rogers, [0073]; FIG. 3.

As explained for limitation [1A], interface object 104 includes “hardware for rendering...tactile feedback” such as “vibration feedback, temperature feedback, pressure feedback, etc.” Rogers, [0073]; *see also* [0112]; FIG. 12. This tactile feedback hardware includes “movable weight 800” and the hardware that controls it “in response to tactile feedback data received from a computer” (i.e., computer 106 in the FIG. 1 system) to produce the “desired haptic effect.” Rogers, [0105].

317. Rogers discloses that the tactile feedback rendered by interface object 104’s tactile feedback hardware can be based on movement of the object. For example, Rogers explains that “when a user reloads their corresponding virtual weapon by, for example, *pointing the directional interface object 104 upward*, the moveable weight 800 may be caused to move so as to mimic the sensation of weapon reloading mechanics of the virtual weapon.” Rogers, [0105].

318. A POSA would have understood that this haptic effect (which is produced in response to tactile feedback data received from computer 106 when the user has moved interface object 104 to point upwards) is determined based on the tracking information that computer 106 receives from camera 108 and interface object 104’s inertial sensor (i.e., “*based in part on data received from the sensor*”) because that is how Rogers discloses detecting the direction that interface object 104 is pointing, as I discussed above in §IX.B.5.a ([1D1]). *See also* §IX.B.4 above (explaining that camera 108 and interface object 104’s inertial sensor both meet

[1C]’s “*sensor*,” either individually or together.) Rogers, [0018], [0044], [0052]-[0053], [0106].

319. Thus, computer 106’s processor performs [1D2] when it determines that the interface object 104 has been pointed upwards in a reloading gesture and provides the “tactile feedback data” ([0105]) to interface object 104’s “tactile feedback hardware” ([0073]) to control moveable object 800 to produce the haptic effect mimicking weapon reloading mechanics.

- c. **[1D3]: “transmit a display signal associated with the modified visual effect to the display, the modified visual effect to be displayed on the proxy object via the display;”**

320. In my opinion, a POSA would have understood that computer 106’s processor performs [1D3] when it outputs the video from the video game for display by HMD 102.

321. As I discussed above in §IX.B.5.a in connection with [1D1], computer 106’s processor determines “*the modified visual effect to be displayed on the proxy object via the display*” when it modifies the appearance of the virtual weapon and the virtual hands holding it to correspond to the detected location and orientation of interface object 104 held by the user. Rogers, [0018], [0043]-[0045], [0052], [0055], [0105]-[0109], FIG. 1.

322. Computer 106’s processor thus “*transmit[s] a display signal associated with the modified visual effect to the display*” when it “*output[s] the*

video” (i.e., “*transmit[s] a display signal*”) of the changing appearance of the virtual hands holding the virtual weapon as the user points interface object 104 in different directions (i.e., [1D1]’s “*modified visual effect*” discussed in §IX.B.5.a above) “for rendering by the HMD 102” (i.e., [1B]’s “*display*”) as claimed.

Rogers, [0043] (disclosing that “computer 106” is “configured to execute a video game, and output the video [] from the video game for rendering by the HMD”); *see also* [0018] (“computing device configured to...render a view of a virtual environment to a head-mounted display (HMD)”); [0070] (“video rendering module 322 is defined to render a video stream for presentation on the HMD”), FIG. 3.

323. A POSA would have understood that the “video...from the video game” ([0043]) is a “*display signal*” and that this video is “*associated with the modified visual effect*” because the video includes the changing appearance of the virtual hands holding the virtual weapon that moves in correspondence with the user’s movement of interface object 104, as I discussed above in §IX.B.5.a regarding [1D1]’s “*modified visual effect*”).

324. HMD 102 displays the “*modified visual effect*” “*on the proxy object*” under patent owner’s broader interpretation for the reasons I discussed above in §IX.B.3 ([1B]’s “*display*”)—i.e., because patent owner’s interpretation encompasses virtual-only displays. §VI. For example, as I discussed above in

§VII.B.5.c (Banerjee ground) with reference to the below image from patent owner’s infringement contentions (EX1006, 10), I understand patent owner to have alleged that that [1D3] is met because “[t]he virtual hand is rendered differently as the controller moves” (EX1006, 10). Rogers likewise renders virtual hands and the virtual weapon differently as the user moves interface object 104 in the manner discussed above. EX1006, 4-10; §VI.



325. In Roger’s AR embodiment (see §IX.B.3 above) computer 106’s processor outputs video “augmented with virtual elements” ([0063]) to HMD 102 for display in the same way as computer 106’s processor transmits video of a VR display to HMD 102 discussed above (*see, e.g.*, [0043], [0070]). Thus, computer 106’s processor outputs augmented video to HMD 102 for display with the changing appearance of the virtual weapon (with or without virtual hands) as the user moves interface object 104 overlaid on the interface object 104 in the captured

video of the environment, as discussed in §§IX.B.3 and IX.B.5.a above. Rogers, [0018], [0043]-[0045], [0063], [0068]-[0071], [0107]-[0109].

d. [1D4]: “transmit a haptic signal associated with the haptic effect to the one or more haptic output devices;”

326. In my opinion, a POSA would have understood that computer 106’s processor performs [1D4] when it transmits tactile feedback data to interface object 104’s tactile feedback hardware that causes moveable weight 800 to produce the desired haptic effect.

327. As I discussed above in §IX.B.5.b ([1D2]), computer 106’s processor “provide[s] *signals* to tactile feedback hardware” included in interface object 104 that renders the desired tactile feedback ([0073]), including by controlling the movement of weight 800 to produce the desired haptic effect. Rogers, [0105] (explaining “movable weight 800” is controlled “in response to tactile feedback data received from a computer”), [0112]. Thus, computer 106’s processor performs [1D4] when it transmits the tactile feedback data to interface object 104’s tactile feedback hardware that, in response, controls moveable weight 800 to “mimic the sensation of weapon reloading mechanics of the virtual weapon” when it is detected that the user has “point[ed] the directional interface object 104 upward” ([0105]), because POSA understood that the “tactile feedback hardware” ([0073])

comprising moveable object 800 and the hardware used to control it to produce the “desired haptic effect” ([0105]) are “*haptic output devices*” as claimed.

e. [1D5]: “output the haptic effect using the one or more haptic output devices.”

328. In my opinion, a POSA would have understood that computer 106’s processor performs [1D5] for the same reason it performs [1D4].

329. Specifically, when computer 106’s processor transmits tactile feedback data to interface object 104’s “tactile feedback hardware” ([0073]) to cause movement of moveable object 800 to “mimic the sensation of weapon reloading mechanics of the virtual weapon” ([0105]), computer 106’s processor uses “*one or more haptic output devices*” (including moveable weight 800 and the hardware that controls it) to “*output the haptic effect*” as claimed. Rogers, [0073], [0105].

C. Claim 2: “The system of claim 1, further comprising a wearable device comprising one or more second haptic output devices.”

330. Rogers’s system includes “*a wearable device comprising one or more second haptic output devices,*” as claimed. As seen below in Figure 1, Rogers’s system includes head-mounted display 102 that a user wears on his head. Rogers, [0005], [0042]-[0046].

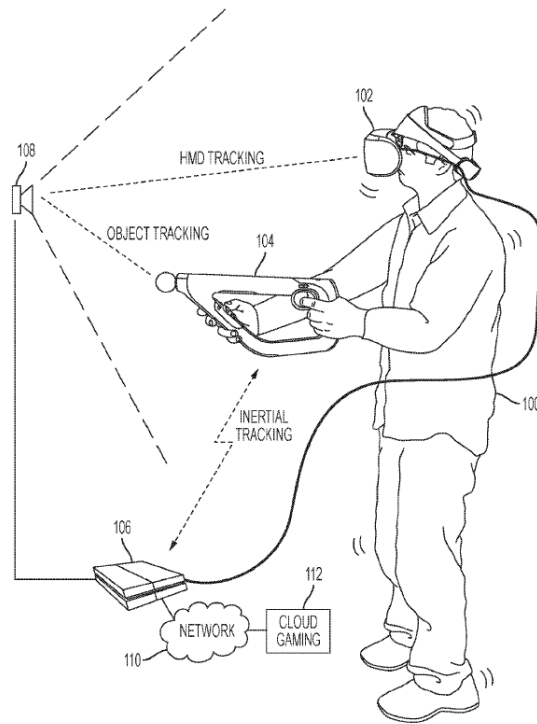


FIG. 1

331. The head-mounted display is a “wearable device,” as claimed. Rogers, [0005] (“head-mounted display is worn by the user”), [0042] (“HMD 102 is worn in a manner similar to glasses, goggles, or a helmet”).

332. Rogers further discloses that the head-mounted display includes “tactile feedback” that “caus[es] movement and/or vibration of the head-mounted display 102 so as to provide tactile feedback to the user.” Rogers, [0125]; FIG. 12; *see also* [0073] (“tactile feedback module 326 is configured to provide signals to tactile feedback hardware included in [] HMD 102.... [and] may take the form of various kinds of tactile sensations, such as vibration feedback, temperature

feedback, pressure feedback, etc.”). Rogers’s head-mounted display 102 thus “*compris[es] one or more second haptic output devices,*” as claimed.

D. Claim 3: “The system of claim 1, wherein the proxy object comprises one or more of: a shoe, an article of clothing, an electronic device, a display, an interface object, or an interior of a vehicle.”

333. As discussed above in §IX.B.2 ([1A]), Rogers’s interface object 104, i.e., the claimed “*proxy object,*” is both an “*electronic device*” and an “*interface object.*” As Rogers explicitly says, ***interface object*** 104 is an “*interface object*” that provides the interface that allows the user to interact with a virtual scene ([0043]-[0046], [0053]-[0055], [0105]-[0109]). Rogers’s interface object 104 also includes tactile feedback hardware for rendering a host of tactile feedback (e.g., “vibration feedback, temperature feedback, pressure feedback, etc.,” [0073]) and that controls moveable object 800 ([0105]), and includes a trackable object 416 that lights up using an LED ([0053], [0081]) and is therefore an “*electronic device*” as claimed.

E. Claim 4: “The system of claim 1, wherein the proxy object comprises neutral physical characteristics.”

334. As shown in FIGS. 10 and 11, Rogers’s interface object 104 has a generic tubular shape (see also [0018]) that can be made to look like a desired “virtual weapon” in the VR display or AR display (see §IX.B.3 above, [0063]). In my opinion, a POSA would have understood that interface object 104 thus

“comprises neutral physical characteristics” in way the ’067 patent describes.

EX1001, 5:34-44 (describing proxy object with “neutral physical characteristics” that is made to look a particular way using a “visual overlay.”).

F. Claim 5: “The system of claim 1, wherein the modified visual effect is configured to modify an appearance of the proxy object through the display.”

335. In my opinion, a POSA would have understood that clam 5 is met for the same reasons that limitation [1D1] is met under patent owner’s interpretation. *See also* EX1006, 26 (alleging claim 5 is co-extensive with limitation [1D1]).

336. As I discussed in §§IX.B.5.a ([1D1]) and IX.B.5.c ([1D3]), as the user moves interface object 104 to control a virtual weapon, [1D1]’s “*modified visual effect*” of the changed appearance of virtual hands holding the virtual weapon at the detected location and orientation of interface object 104 as it moves is displayed by HMD 102 (e.g., as shown in Figures 10 and 11 below for one such detected location and orientation, respectively). Rogers, [0043]-[0044], [0052]-[0053], [0068]-[0070]. Under patent owner’s interpretation, this changed appearance meets “*modify[ing] an appearance of the proxy object through the display*” for the reason I discussed in §§IX.B.3 and IX.B.5.a with respect to [1B]’s “*display*” and [1D1]’s “*modified visual effect*, respectively. *See* EX1006, 10, 26.

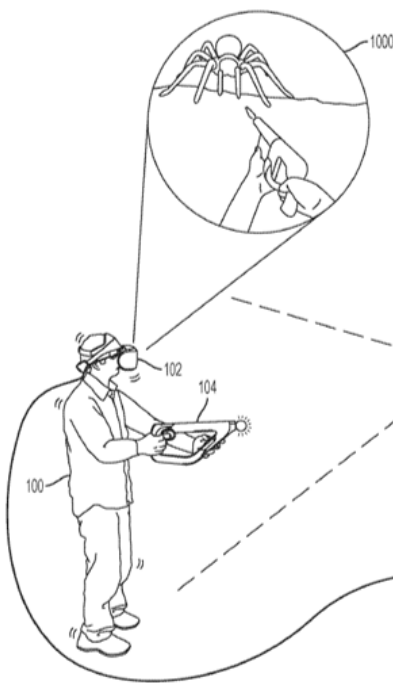


FIG. 10

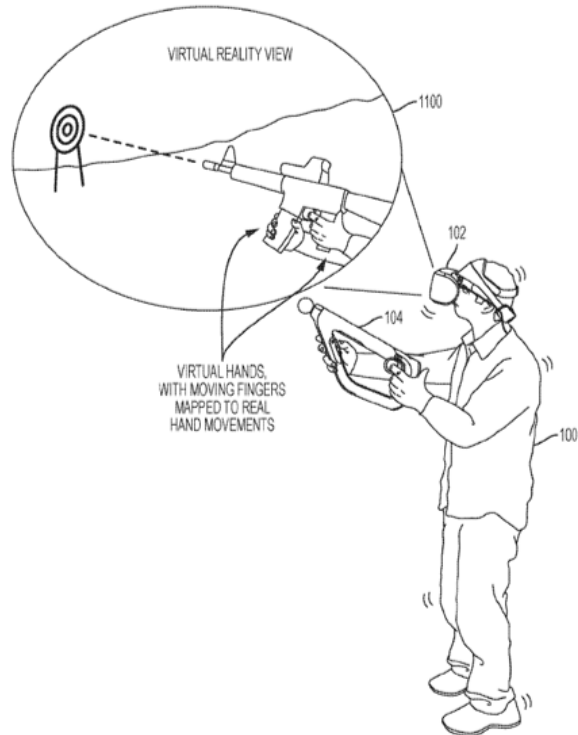


FIG. 11

G. Claim 6: “the display comprises...a wearable device”

337. As I discussed above in §IX.D with respect to claim 3, the head-mounted display 102, i.e., the claimed “*display*,” is a “*wearable device*,” as claimed.

H. Claim 7: “The system of claim 1, wherein the sensor comprises at least one of a camera, a laser, a radar, an accelerometer, a gyrometer, a pressure sensor, a magnetic sensor, a light sensor, a tracking sensor, or a microphone.”

338. As I discussed above in §IX.B.4 with respect to [1C], Roger’s camera 108 meets [1C]’s “*sensor*” and is a “*camera*,” meeting claim 7. As also discussed with respect to [1C], interface object 104’s inertial sensor also meets [1C]’s “*sensor*” for which Roger’s gives “a magnetometer” (“*magnetic sensor*”),

“*accelerometer*,” or “gyroscope” (“*gyrometer*”) as examples. Rogers, [0111].

Rogers thus meets claim 7 for this separate reason.

I. Claim 8: “the processor is further configured to receive an input signal from an input capture device and determine the haptic effect based in part on data received from the input capture device.”

339. In my opinion, a POSA would have understood that claim 8 is met for multiple reasons.

340. First, camera 108 is an “*input capture device*” because it “capture[s] images of the interactive environment in which the user 100 is located” ([0044])—i.e., the input that camera 108 captures is the interactive environment. Rogers, [0044], [0053]. Indeed, image capture by camera 108 is what allows computer 36 to track the “location and movements of the user 100, the HMD 102, and the directional interface object 104.” Rogers, [0044], [0053] (“tracking can be achieved by monitoring captured image frames of the scene in which the user 100 is playing, which can detect the position of the HMD 102, and the directional interface object 104.”).

341. Computer 106’s processor performs claim 8 because it receives and uses the “captured images” ([0044]) from camera 108 (i.e., “*an input signal from an input capture device*”) to detect when user 100 has pointed interface object 104 upwards in a reloading gesture and transmit the tactile feedback data to interface object 104’s tactile feedback hardware to control moveable weight 800 to “mimic

the sensation of weapon reloading mechanics of the virtual weapon” ([0105]), as discussed in §§IX.B.5.b, IX.B.5.d, IX.B.5.e in connection with determining, transmitting, and outputting [1D2]’s “*haptic effect*.”

342. Second, computer 106’s processor is configured to receive commands from various “selection buttons” that are disposed on interface object 104. Rogers, [0051]-[0052]; *see also* [0069] (explaining that the game engine receives “controller input” from, *inter alia*, “button presses”). Rogers’s buttons are “*input capture device[s]*,” as claimed because the user provides “controller input” to the game via “button presses.” Rogers, [0069].

343. The ’067 patent identifies a wide range of “*input capture device[s]*,” including “an audio capture device, a touchscreen, a keyboard, a mouse, a joystick, or an augmented reality control board” that are used to select a color/texture to be displayed on the proxy object. EX1001, 5:50-53; *see also* 8:34-39. Thus, the ’067 patent’s input capture devices are conventional input devices used in the conventional way—i.e., to instruct the processor to perform a particular set of functionality.

344. A POSA would have understood that interface object 104’s “selection buttons,” which are described as being similar to those that “are common to various other game console controllers” ([0051]), would be used for common purposes such as selecting a videogame to play or selecting a weapon to use in a

particular video game. [0059] (describing navigating screens or menus and selecting interfaces can be done using interface object 104 buttons). Computer 106's processor would thus perform claim 8 when executing a video game selected via interface object's "selection buttons" in which [1D2]'s "*haptic effect*" is part of the game play (e.g., a first-person shooter game) and/or when a reloadable weapon is selected for which [1D2]'s "*haptic effect*" is part of the virtual weapon's programmed functionality. Rogers, [0051], [0059].

345. Separately, in the pending district court litigation patent owner alleges that "*the haptic effect*" recited in claim 8 need not be the same "*haptic effect*" recited in limitation [1D2]. *Compare* EX1006, 14-18 (mapping [1D2] to controller movement) *with id.*, 28-29 (mapping claim 8 to trigger pulls). Rogers discloses claim 8 under this alternative interpretation as well because Rogers teaches that interface object 104 includes a trigger that can be used to "fire a virtual weapon" ([0050]) and that doing so causes the movable weight in the object to move thereby "providing a kickback sensation similar to that of an actual weapon." Rogers, [0105].

J. Claim 11

346. Claim 11 recites the method that claim 1's processor is configured to perform. Thus, Rogers's system meets claim 11 for the same reason it meets claim 1 that I discussed in §IX.B above, including each of claim 11's method steps

performed by computer 106's processor as I discussed in §§IX.B.5.a-IX.B.5.e above.

K. Claim 12

1. [12A]

347. As I discussed above in §IX.B.5.b with respect to [1D2], Roger's "tactile feedback module 326" executed by computer 106's processor when executing game engine 320 (see §IX.B.5) that determines a first haptic effect ([1D2]'s "*haptic effect*") for interface object 104 (as discussed above for [1D2]) also provides signals to tactile feedback hardware "included in [the] HMD." Rogers, [0073]; *see also* [0125]. Thus, computer 106's processor is therefore configured for "*determining a second haptic effect,*" meeting [12A].

2. [12B]

348. As discussed above for [12A], Rogers's "tactile feedback module 326" executed by computer 106 is "configured to provide *signals* to tactile feedback hardware included in [the] HMD." Rogers, [0073]; [0125]. The "tactile feedback hardware" within the HMD are "*one or more second haptic output devices,*" as claimed.

3. [12C]

349. As discussed above for [12B], in response to a signal from computer 106's processor, the "tactile feedback hardware" within the HMD "caus[e] movement and/or vibration of the [HMD] so as to provide tactile feedback to the

user.” Rogers, [0125]; *see also* [0073]. Computer 106’s processor is thus configured to “*output[] the second haptic effect using the one or more second haptic output devices,*” as claimed. POSAs would have understood Rogers’s disclosure that the “tactile feedback hardware” is “included in” HMD 102 to mean, or at least suggest, the hardware is “*mechanically coupled to*” the HMD, i.e., “*a wearable device,*” as claimed, because mechanically coupling would be the way the user would feel the tactile feedback, or that would have been the obvious and conventional way to render the disclosed tactile feedback. Rogers, [0073], [0125].

350. POSAs would have recognized multiple obvious and desirable uses for HMD 102’s tactile feedback capabilities, such as rendering a tactile sensation of being “hit” by a virtual enemy’s weapon in the virtual scene (or another player’s virtual weapon) and/or to render tactile feedback to indicate detrimental contact has been made with other virtual objects in the environment (e.g., FIG. 9’s bear or FIG. 10’s spider), etc. Rogers, [0073], [0105]-[0109], [0125]; EX1035, [0045]-[0056] (disclosing a variety of haptic feedback transmitted to a user’s headset during game play that would have been obvious to a POSA to use).

L. Claim 15: “The method of claim 11, wherein the proxy object comprises one or more of: a shoe, an article of

clothing, an electronic device, a display, an interface object, or an interior of a vehicle.”

351. In my opinion, a POSA would have understood that Rogers meets claim 15 for the reasons I discussed in §IX.D above for claim 3’s identical limitations.

M. Claim 16: “The method of claim 11 wherein the proxy object comprises neutral physical characteristics.”

352. In my opinion, a POSA would have understood that Rogers meets claim 16 for the reasons I discussed in §IX.E above for claim 4’s identical limitations.

N. Claim 17: “The method of claim 11, wherein the modified visual effect is configured to modify an appearance of the proxy object through the display.”

353. In my opinion, a POSA would have understood that Rogers meets claim 17 for the reasons I discussed in §IX.F above for claim 5’s identical limitations.

O. Claim 18: “The method of claim 11, wherein the display comprises at least one of: a wearable device or a mobile device.”

354. In my opinion, a POSA would have understood that Rogers meets claim 18 for the reasons I discussed in §IX.G above for claim 6’s identical limitations.

P. Claim 19: “The method of claim 11, wherein the sensor comprises at least one of a camera, a laser, a radar, an

accelerometer, a gyrometer, a pressure sensor, a magnetic sensor, a light sensor, a tracking sensor, or a microphone.”

355. In my opinion, a POSA would have understood that Rogers meets claim 19 for the reasons I discussed in §IX.H above for claim 7’s identical limitations.

Q. Claim 20: “The method of claim 11, further comprising receiving an input signal from an input capture device and determining the haptic effect based in part on data received from the input capture device.”

356. In my opinion, a POSA would have understood that Rogers meets claim 20 for the reasons I discussed in §IX.I above for claim 8’s identical limitations.

R. Claim 21

357. Claim 21 recites “*non-transitory computer-readable medium comprising program code*” to cause a processor to perform the method of claim 11 i.e., the steps that claim 1’s processor is configured to perform.

358. Rogers teaches that its “disclosure can also be embodied as computer readable code” (i.e., “*program code*”) “on a computer readable medium.” Rogers, [0155]. Rogers likewise discloses that “various general-purpose machines,” e.g., computer 106 (FIG. 1) “can be used with computer programs written in accordance with the teachings herein.” Rogers, [0154]; *see also* [0147] (explaining processor for video server is programmed with “software instructions”).

359. Thus, a POSA would have understood that computer 106 includes Roger's "computer readable medium" that a POSA would have understood is "*non-transitory*" because it stores "computer readable code" of the video game and is thus not a transitory signal that I understand from Valve's counsel the term "non-transitory" is meant to exclude. POSAs understood that computer 106's processor meets claim 21 when it executes the video game's computer readable code (see [0043]) (e.g., FIG. 3's game engine 320) for the same reasons discussed above in §§IX.B.5.a-IX.B.5.e.

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

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

Dated: 06 FEB 2024