

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

VALVE CORPORATION,
Petitioner,

v.

IMMERSION CORPORATION,
Patent Owner.

Case No. TBD
Patent No. 9,116,546

**DECLARATION OF GREGORY WELCH, Ph.D.
IN SUPPORT OF VALVE CORPORATION'S PETITION FOR
INTER PARTES REVIEW OF U.S. PATENT NO. 9,116,546**

Valve Exhibit 1003 Valve v. Immersion
--

TABLE OF CONTENTS

I.	INTRODUCTION	1
A.	Engagement	1
B.	Background and Qualifications	2
C.	Bases of My Opinions and Materials Considered	11
D.	My Understanding of Patent Law	12
1.	Anticipation	13
2.	Obviousness	14
II.	DESCRIPTION OF THE RELEVANT FIELD AND THE RELEVANT TIME FRAME	18
III.	LEVEL OF ORDINARY SKILL IN THE ART	19
IV.	THE '546 PATENT	23
A.	Summary of the '546 Patent	23
B.	Prosecution History	29
C.	Challenged Claims	33
V.	GROUND FOR UNPATENTABILITY	34
A.	Ground 1: Rosenberg Anticipates and/or Renders Obvious Claims 1-18, 21-24, and 26-29	34
1.	Rosenberg (EX1009)	34
2.	Claim 1	43
a.	[1PRE]: “A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:”	43
b.	[1A]: “receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;”	47
c.	[1B]: “mapping the received input to a haptic signal; and”	51

d. [1C]: “sending the haptic signal to an actuator to generate the haptic effect;”	56
e. [1D]: “the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input;”	59
f. [1E]: “the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.”.....	68
3. Claim 2: “The non-transitory computer-readable medium of claim 1, the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value.”	69
4. Claim 3: “The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.”	71
5. Claim 4: “The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a deformation actuator, and wherein the haptic effect generated by the deformation actuator comprises a deformation haptic effect.”	72
6. Claim 5	76
7. Claim 6	77
8. Claim 7	77
9. Claim 8	77
10. Claim 9	78
a. [9PRE]: “A haptic representation system comprising:”	78
b. [9A]: “a memory configured to store a haptic representation module;”	80
c. [9B]: “a processor configured to execute the haptic representation module stored on the memory;”	81

d. [9C]: “an actuator configured to output one or more haptic effects;”	82
e. [9D]-[9H]	83
11. Claim 10	83
12. Claim 11	83
13. Claim 12	83
14. Claims 13, 21, and 26.....	84
15. Claims 14, 22, and 27.....	86
16. Claims 15, 23, and 28.....	86
17. Claim 16	87
18. Claims 17, 24, 29.....	87
19. Claim 18	88
B. Ground 2: Brock Anticipates and/or Renders Obvious	
Claims 1-3, 5-7, 9-11, 13-16, 21-23, and 26-28.....	89
1. Brock (EX1008)	89
2. Claim 1	97
a. [1PRE]: “A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:”	97
b. [1A]: “receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;”	105
c. [1B]: “mapping the received input to a haptic signal; and”	108
d. [1C]: “sending the haptic signal to an actuator to generate the haptic effect;”	109

e.	[1D]: “the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and”	112
f.	[1E]: “the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.”	114
3.	Claim 2: “The non-transitory computer-readable medium of claim 1, the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value;”	115
4.	Claim 3: “The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.”	118
5.	Claim 5	118
6.	Claim 6	119
7.	Claim 7	119
8.	Claim 9	119
a.	[9PRE]: “A haptic representation system comprising:”	119
b.	[9A]: “a memory configured to store a haptic representation module;”	120
c.	[9B]: “a processor configured to execute the haptic representation module stored on the memory; and”	120
d.	[9C]: “an actuator configured to output one or more haptic effects;”	121
e.	[9D]-[9H]	121
9.	Claim 10	121
10.	Claim 11	122
11.	Claims 13, 21, and 26.....	122

12. Claims 14, 22, and 27	123
13. Claims 15, 23, and 28	124
14. Claim 16	124
VI. CONCLUSION.....	124
APPENDIX A: MATERIALS CONSIDERED	126
APPENDIX B: U.S. PATENT NO. 9,116,546 CLAIM LIST	128

I, Gregory F. Welch, declare:

I. INTRODUCTION

A. Engagement

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 my opinions concerning the patentability of claims in U.S. Patent No. 9,116,546 (EX1001, “the ’546 patent”), specifically claims 1-18, 21-24, and 26-29 (the “challenged claims”). I make this Declaration in support of Valve’s IPR petition.

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 matter 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. Other than my hourly rate (and reimbursement for expenses) I have no personal or financial stake or interest in the outcome of this proceeding. I do not have any expectation or promise of additional business with the Petitioner or its counsel in exchange for my work on the matter or my opinions explained herein.

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

B. Background and Qualifications

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 was 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. 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 27,000 citations, and I am a co-inventor on 26 issued patents with one pending and several more in prosecution. 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 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 (haptic) 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 something we refer to as *smart moulage* in 2019–2022. 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. This work has 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 our physical-virtual patient bed. These are patient simulators that, among other things, incorporate 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. The strength and timing of the tactile feedback can be varied to simulate a strong or weak (“thready”) pulse. 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. We have also incorporated 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.)

18. 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.)

C. Bases of My Opinions and Materials Considered

19. In connection with my work on this matter, I have reviewed the ’546 patent, its prosecution history, and the prior art and other documents and materials cited herein. For ease of reference, the full list of documents that I have considered is included in Appendix A. I have also considered the documents cited and referenced herein, even if not included in Appendix A. 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.

20. 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 ’546 patent, as described in Section III below.

21. The opinions and comments formulated during this assessment are based on observations and information available to me at the time of this investigation. If additional information becomes available, for example in materials submitted by the Patent Owner, I would be happy to consider such additional information and offer my thoughts thereon if requested to do so.

D. My Understanding of Patent Law

22. In developing my opinions, I discussed various relevant legal principles with Petitioner's attorneys. I have relied upon such legal principles, as explained to me, while forming the opinions set forth in this Declaration. My understanding in this respect is as follows:

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

24. I understand that, in this proceeding, Valve has the burden of proving that the challenged claims of the '546 patent are unpatentable by a preponderance of the evidence. I understand that a "preponderance of the evidence" means that the evidence establishes that a fact or conclusion is more likely true than not true.

25. I understand that patent claims can be independent or dependent. I understand that a dependent claim must reference a claim previously set forth, and

then must specify a further limitation of the claimed subject matter. I also understand that a dependent claim is treated as incorporating by reference all limitations of the claim(s) from which it depends. I understand that an independent claim does not usually reference or incorporate limitations from other claims.

26. I understand that, in IPR proceedings, claim terms in a patent are given their ordinary and customary meaning as understood by a POSA in the context of the entire patent and the prosecution history pertaining to the patent. I discuss the qualifications of the POSA relevant to the '546 patent in Section III below. I understand that if the patent specification provides a special definition for a claim term that differs from the meaning the term would otherwise possess, the specification's special definition takes precedence. I have applied these standards in preparing the opinions in this Declaration.

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

1. Anticipation

28. I understand that, for a patent claim to be "anticipated" by the prior art (and therefore not novel), each and every claim limitation of the claim must be disclosed, actually 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.

29. 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 POSA recognized the presence of that limitation in the prior art.

2. Obviousness

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

31. 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 claimed subject matter, as a whole, would have been obvious to a POSA 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 '546 patent, but if any secondary considerations are later presented, I would be happy to evaluate and comment thereon if asked to do so.

32. I understand that for a claimed invention to be 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.

33. 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.

34. 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.

II. DESCRIPTION OF THE RELEVANT FIELD AND THE RELEVANT TIME FRAME

35. I have reviewed the '546 patent (EX1001) and its prosecution history (EX1002).

36. I understand that the '546 patent issued from U.S. Patent Application Serial No. 13/597,300, filed on August 29, 2012. EX1001 (Fields 21 & 22).

37. I have been instructed by Valve's counsel to assume that the relevant time frame for my analysis of the prior art in this Declaration is on or before August 29, 2012. I use that time frame for all the analysis in this Declaration. By way of example (and without limitation), when I speak about what a POSA would have understood from reading a document, or what would have been obvious to a POSA in view of one or more documents, I do so with the aforementioned time frame in mind.

38. Based on my review of the '546 patent, the relevant general fields for the purposes of the '546 patent are hardware and software designs for electronic devices that provide haptic feedback to a user.

39. Haptic feedback refers to an effect or sensation that a user can perceive via the user's sense of touch. The word "haptic" means relating to a sense

of touch, and sometimes is used synonymously with the word “tactile.” “Tactile” is also used to refer to fine grain sensations like texture, friction, etc. Generally speaking, electronic devices may use different types of cues such as visual, auditory, and haptic cues or feedback, and sometimes electronic devices use a combination of more than one type of feedback, to deliver information to a user such as to alert the user of certain events. Haptic feedback can enhance the experience of a user by providing cues that do not require the user to see or hear the device. A vibrational alert from a mobile phone is one example. Haptic feedback is not limited to vibration, and includes a wide range of sensations, including forces exerted by the devices and changes in the texture of a device’s surface.

III. LEVEL OF ORDINARY SKILL IN THE ART

40. My opinions are based on what a person of ordinary skill in the art (“POSA”) in the technical field of the ’546 patent would have understood at the time of the alleged invention of the ’546 patent. As I explained above, the relevant time frame for the analysis in this Declaration is on or before August 29, 2012. I understand that the contents of a patent and prior art references thereto should be understood the way a POSA would have understood the subject matter at the time of the alleged invention.

41. I was asked to provide an opinion as to the level of ordinary skill in the art pertinent to the subject matter of the '546 patent on or before August 29, 2012. 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.

42. In my experience, people who designed and worked on electronic devices that provide haptic feedback to users (the general field of the '546 patent) before August 2012 had relevant technical backgrounds through education, and generally had at least some work experience too (although everyone has to start somewhere and a newly graduated engineer could work on such a project as a first task after graduation, even if he or she would generally do so as part of a team of others with more experience)—but not necessarily advanced technical degrees. I briefly reviewed the backgrounds of the named inventors of the '546 patent, and their backgrounds in 2012 were consistent with my view as I just described. According to LinkedIn, in 2012, the first named inventor David Birnbaum had a Bachelor of Science in Music Industry with Business Emphasis and a Master of Arts in Music Technology, and a number of years of experience in “user experience design.” Named inventor Christopher Ullrich had bachelor’s and

master's degrees in applied mathematics and experience that included work with cloud services, physical prototypes, and user interface design. Named inventor Danny Grant had a Ph.D. in electrical engineering. Named inventor Ali Modarres had a Ph.D. in mechatronics engineering, robotics, and human-computer interaction and engineering experience with haptics. Named inventor Juan Manuel Cruz-Hernandez does not appear to have a LinkedIn page, but there is a profile of him on IEEE Xplore (the IEEE digital library), and that profile indicates he has a B.S. in computer engineering and a Ph.D. in the area of applied control. These individuals appear to have had, at the time the '546 patent was filed, a variety of different skill-sets and educational backgrounds, which likely compensated for one another since not every member of a team necessarily has all of the experience needed for a given project—which is why engineers and product designers work on teams. In my opinion, the overall mix of technical education and experience with human-computer interaction of the '546 patent inventors, as well as my personal experience with similar projects before August 2012, leads me to the conclusion that a person of ordinary skill in the art of the '546 patent in August 2012 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 '546 patent and the prior art references discussed in this Declaration.

43. In addition to reviewing the backgrounds of several of the '546 patent inventors who I found on LinkedIn, I am also familiar with the level of ordinary skill in the art based on my own technical experience and my interaction with students and professionals who were working on similar devices in 2012 and earlier. I actively taught and carried out research with such students and professionals in the years leading up to 2012. For example, in the late 1990s I taught a graduate-level course at the University of North Carolina at Chapel Hill called Exploring Virtual Worlds, and course coverage included the perceptual and technical aspects of haptics, tactile sensations, and force feedback. The course also included a final project, and various related devices and techniques were sometimes used in the projects. In the early 2000s I collaborated some on a multidisciplinary project to develop a 3D Force Microscope (3DFM). The 3DFM included some elements of haptic feedback associated with the forces on a magnetically controlled / sensed bead freely suspended in liquid. My experience informs the conclusion I just articulated about the level of ordinary skill in the art.

44. As summarized above regarding my qualifications and experience, I possessed at least the ordinary level of skill in the art at the time of the alleged invention of the '546 patent.

45. 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 August 2012. 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 August 2012 time frame. Even though I had greater than the ordinary level of skill in the art as of 2012 (since I earned my Ph.D. in 1997 and had about 15 years of post-Ph.D. experience by 2012), 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 August 2012) people having an ordinary level of skill and experience in the field of the '546 patent, including most of the students I have advised or co-advised.

IV. THE '546 PATENT

A. Summary of the '546 Patent

46. The '546 patent is titled “system for haptically representing sensor input.” EX1001, cover.

47. The '546 patent discloses “a device that produces haptic effects.” EX1001, 1:6-7. In the Background section, the patent introduces “[h]aptics” as “a tactile and force feedback technology that takes advantage of a user’s sense of touch by applying haptic feedback effects (i.e., ‘haptic effects’), such as forces, vibrations, and deformations, to the user.” EX1001, 1:11-24. Using haptic effects, including forces, vibrations and deformations, to deliver feedback to a user of a

device, was well-known in the prior art before the '546 patent. I will discuss specific prior art references disclosing the use of haptic effects to deliver feedback to users of devices later in this Declaration.

48. The patent describes a “haptic representation system that can produce a haptic effect that represents input that is generated by a sensor and received by the haptic representation system.” EX1001, 2:13-15. Figure 1 illustrates a block diagram of such a haptic representation system 10, which can “represent the sensor input as haptic output.” EX1001, 2:42-45, 4:16-19, Fig. 1. The components shown in this figure were conventional long before the '546 patent. For example, actuators were routinely used to deliver haptic effects, sensors were routinely used to sense conditions that would make it desirable to deliver haptic effects, and processors and operating systems were conventional computer components.

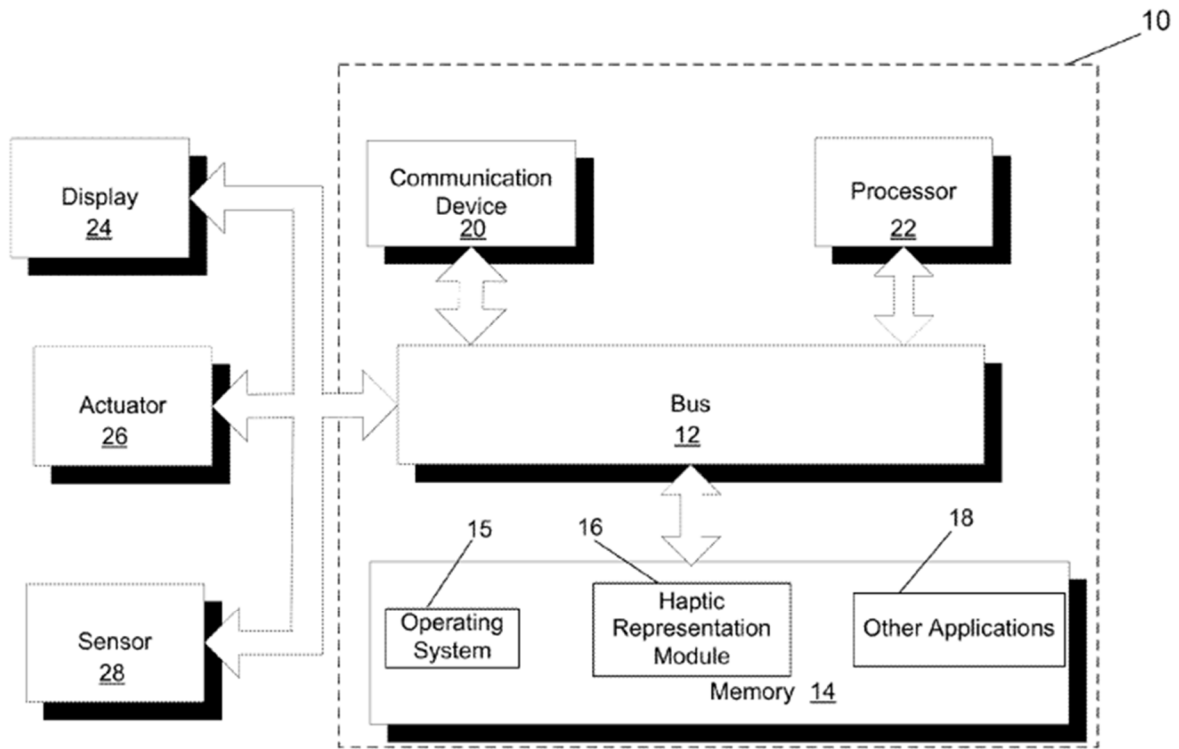


Fig. 1

49. The “haptic representation system” in the ’546 patent can be part of a “device” such as device 200 as illustrated in Figure 2. EX1001, Fig. 2, 2:42-45, 4:16-19.

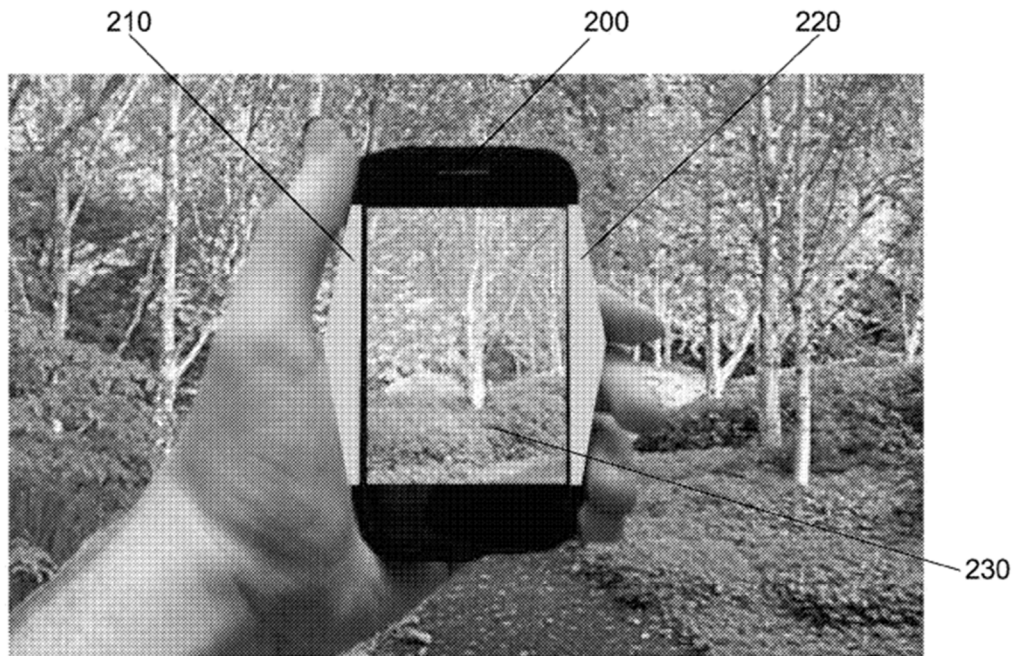


Fig. 2

50. Figure 3 of the '546 patent depicts a device 300 that “may be a cellular phone, a PDA, a smart phone, a laptop computer, a game console, and/or a handheld electronic device capable of...providing haptic feedback.” EX1001, 4:41-54. Such devices routinely employed haptic effects before the '546 patent application was filed in 2012.

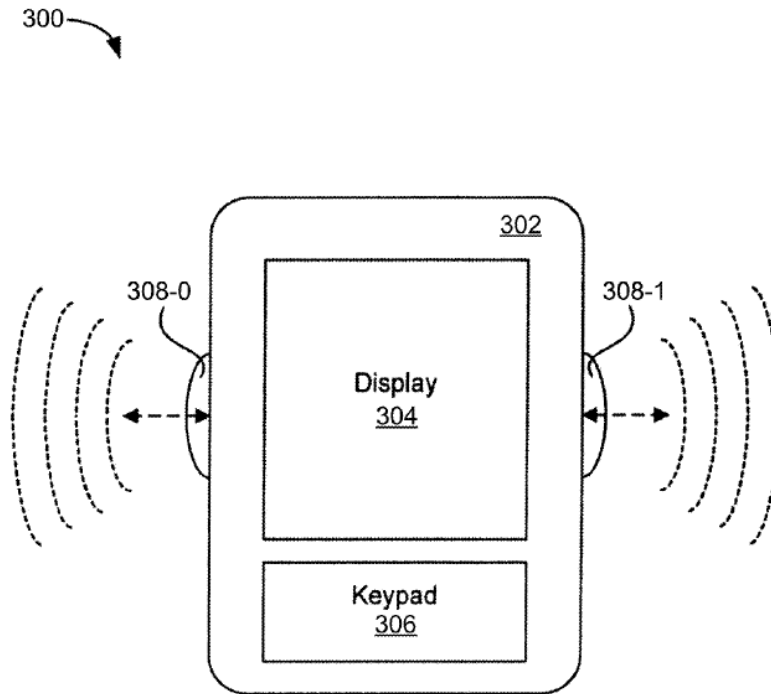


Fig. 3

51. The '546 patent explains that device 300 can provide haptic feedback in several ways, including by employing “vibration haptic effects” that may convey “confirmation of button clicks,” “deformation haptic effects” such as “activation of deformable surfaces at different locations on the handheld device” that “may allow a handheld device to be used as a directional navigation tool,” and “[f]orce haptic effects” that may, for instance, provide a “jerk sensation.” EX1001, 4:41-45, 5:14-59.

52. As noted above, devices that provide haptic feedback to a user were known in the prior art before the '546 patent. I will discuss specific examples of such devices later in my Declaration.

53. The '546 patent explains that haptic feedback is generated based on information obtained from a sensor. In particular, the '546 patent focuses on sensing “extra-sensory information” which it describes as “information that cannot normally be perceived by a human being.” EX1001, 2:17-19, 4:23-28, 6:39-43, 6:66-7:2, 9:12-20, 10:2-5, 11:56-60, 12:63-67, 15:12-19. The '546 patent describes examples of “extra-sensory information” as “electromagnetic field, infra-red light, ultraviolet light, radiation, or subtle changes in temperature.” EX1001, 2:17-20, 6:39-45, 9:12-20, 11:14-18. The '546 patent identifies “a magnetometer configured to detect electromagnetic fields” as an example of a sensor “configured to detect extra-sensory information.” EX1001, 6:40-45; *see also* EX1001, 2:13-20, 7:30-31, 8:23-31, 9:18-19, 10:35-42, 15:23-25, 16:19-23.

54. The '546 patent explains that a “haptic representation module” (as shown in Figure 1) is “software” that “generates a haptic effect that represents received input.” EX1001, 3:8-15, Figs. 1, 4, 5. In particular, the haptic representation module “can include an algorithm that maps the sensor input to an output signal, where the output signal is configured to produce an output effect when played at output device.” EX1001, 6:62-66, 7:21-24, 12:1-5, 13:9-13, 14:23-27, Figs. 4, 5, 8-10. In other words, the device evaluates data received from a sensor and, based on those data, decides whether and what type of haptic sensation to deliver to a user. The '546 patent uses the term “mapping” to describe the

process of turning sensor data into a signal that commands an actuator to deliver a particular haptic sensation to a user. For example:

In certain embodiments, the mapping performed at representation module 410 includes determining whether the received sensor input exceeds a specified threshold (i.e., “specified value”). If the received sensor input exceeds the specified value, a corresponding output signal (such as a haptic signal) is generated, and the received sensor input is mapped to the generated output signal. If the received sensor input does not exceed the specified value, no output signal is generated.

EX1001, 7:53-61.

In “alternate embodiments,” the ’546 patent explains that:

the mapping performed at representation module 410 includes mathematically transforming the received sensor input into a corresponding output signal (such as a haptic signal). This can be done continuously as sensor input is received, and thus, the corresponding output signal can be continuously modulated. As the output signal is continuously modulated, the corresponding output effect (such as a haptic effect) that is generated can also be continuously modulated.

EX1001, 7:62-8:3.

B. Prosecution History

55. I have reviewed the prosecution history of the ‘546 patent (EX1002).

56. In the application as initially filed, claim 1 read as follows:

1. A computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:

receiving input from a sensor, wherein the input comprises extra-sensory information;

mapping the received input to a haptic signal; and

sending the haptic signal to an actuator to generate the haptic effect.

EX1002, 44.

57. The Examiner rejected the claim as unpatentable over prior art.

EX1002, 111-126.

58. In response, the applicants amended claim 1 as follows:

1. (Currently Amended) A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:

receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;

mapping the received input to a haptic signal; and

sending the haptic signal to an actuator to generate the haptic effect;

the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and

the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.

EX1002, 138-150.

59. The applicants argued that the newly-recited modulation distinguished over the prior art. EX1002, 150-157. When presenting their argument to the Examiner, the applicants pointed to the “continuously modulated” language of paragraph [0041] in the application-as-filed:

One embodiment is a haptic representation system that can produce a haptic effect that represents input that is generated by a sensor and received by the haptic representation system. *See e.g.*, Specification at paragraph [0016]. The haptic representation system can receive sensor input from a sensor, map the sensor input to a haptic signal, and send the haptic signal to an actuator. *See e.g.*, Specification at paragraph [0027]. In one embodiment, the mapping can include transforming the received sensor input into the corresponding haptic signal. *See e.g.*, Specification at paragraph [0041]. This can be done continuously as sensor input is received, and thus, the corresponding output signal can be continuously modulated. *See id.* As the output signal is continuously modulated the corresponding haptic effect that is generated can also be continuously modulated. *See id.*

EX1002, 151-152.

60. Paragraph [0041] of the application as filed, which describes a “continuously modulated” haptic signal mapped by “mathematically transforming the received sensor input into a corresponding...haptic signal” (EX1002, 152) is included in the issued ’546 patent at Column 7, line 62 through Column 8, line 3. EX1001, 7:62-8:3.

61. Originally-filed dependent claim 2 read as follows:

2. The computer-readable medium of claim 1, wherein the received input comprises one or more interaction parameters, wherein each interaction parameter comprises a value;

the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value.

EX1002, 44.

62. Originally-filed dependent claim 3 read as follows:

3. The computer-readable medium of claim 1, wherein the received input comprises one or more interaction parameters, wherein each interaction parameter comprises a value;

the mapping the received input to the haptic signal further comprising continuously modulating the haptic signal based on a continuous updating of the value of at least one interaction parameter.

EX1002, 44.

63. During prosecution, the applicants incorporated claim 3's substance into independent claim 1, but deleted "continuously" and "continuous":

1. (Currently Amended) A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:

receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;

mapping the received input to a haptic signal; and

sending the haptic signal to an actuator to generate the haptic effect;

the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and

the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.

2. (Currently Amended) The non-transitory computer-readable medium of claim 1, ~~wherein the received input comprises one or more interaction parameters, wherein each interaction parameter comprises a value;~~

the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value.

3. (Cancelled)

EX1002, 141-142.

C. Challenged Claims

64. I have reproduced the challenged claims at the end of this Declaration as Appendix B, which I received from Petitioner's counsel so that I could reference claim elements in the same manner as Valve's Petition. Throughout this Declaration, when I refer to a claim element by reference number (such as [1A],

[1B], etc.), I mean claim language associated with the referenced claim element as shown in the claim list in Appendix B.

V. GROUNDS FOR UNPATENTABILITY

A. Ground 1: Rosenberg Anticipates and/or Renders Obvious Claims 1-18, 21-24, and 26-29

1. Rosenberg (EX1009)

65. I refer to U.S. Patent Application Publication 2007/0106457 (EX1009) as “Rosenberg” because the inventor is Louis B. Rosenberg. Rosenberg’s cover page reflects that it was published on May 10, 2007. I understand from counsel that Rosenberg qualifies as indisputable prior art to the ‘546 patent because it was published more than one year before the ‘546 patent’s filing date of August 29, 2012.

66. Rosenberg discloses a “portable computing device having a geospatial haptic compass.” EX1009, Title, [0002], [0016]. An example of Rosenberg’s portable computing device is shown in Figure 1, which I have reproduced below.

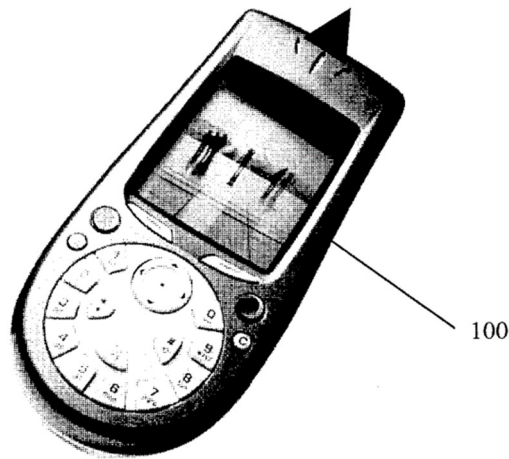


FIG. 1

67. As is likely familiar to most, a compass is a device that one uses to determine a geographic direction. For example, one can use a compass to navigate by checking whether one is heading north, south, east, west (these are known as cardinal directions), or in a direction in-between those cardinal directions.

68. Rosenberg is directed to a device that uses haptic (tactile) feedback to alert a user as to the direction in which the device is pointed. While a common way of using a compass is to inspect it visually, using haptic functionality as described in Rosenberg may be helpful for a variety of reasons. For example, as Rosenberg explains, haptic feedback may allow a user to determine direction more quickly than visual inspection. EX1009, [0030]. In addition, using haptic feedback allows a user to determine a direction without needing to look at the compass, for example if the user wishes to keep the compass in his or her pocket,

or if the user is navigating in heavy snow or rain or other conditions making visibility poor, or if the user has poor eyesight.

69. Rosenberg's device provides "tactile feedback to a user corresponding to a direction of orientation of the portable computing device." EX1009, [0002]. Specifically, Rosenberg's embodiments "enable a user of a portable computing device with geospatial sensing capabilities to feel tactile cues as he or she varies the orientation of the portable computing device with respect to the earth." EX1009, [0007]. This orientation with respect to the earth is sometimes also called a geospatial orientation. The geospatial orientation of Rosenberg's device can be varied by a user to be "aimed and/or aligned with particular orientations," such as by aiming a molded arrow indicator on the device (shown in Figure 1) to the particular orientation. EX1009, [0022]. For example, a user can aim Rosenberg's device to be aligned with a cardinal direction. EX1009, [0007].

70. Rosenberg's device senses its geospatial orientation and outputs a tactile sensation, e.g., vibration or texture sensation, as the user "varies the orientation of the...device with respect to the earth." EX1009, [0007], [0025]-[0026], [0036], [0043], [0047], [0050], [0076]. For example, the device can provide a tactile sensation when pointed due north. EX1009, [0008], [0028]. This tactile (haptic) sensation can communicate direction to the user so that the user does not have to inspect the compass visually.

71. The geospatial orientation reading from Rosenberg's device may be a "tilt-compensated heading" to account for "tilt angles for the portable computing device 100 (or aimable portion thereof)." EX1009, [0025]. However, tilt-compensation is not always necessary, as Rosenberg makes clear that a "two-axis compass can remain accurate as long as the sensors remain horizontal with respect to the surface of the earth, or orthogonal to the gravitational (downward) vector." EX1009, [0024], [0026]. A POSA would therefore understand from Rosenberg's instructions how to hold Rosenberg's device to sense its geospatial orientation. However, optional tilt compensation can be helpful in some cases, to allow the device to function properly even when not held horizontally (for example, if a user is holding the device in a pocket, where it can be difficult to keep it horizontal).

72. I have reproduced Figure 3 of Rosenberg below, which shows a "computational architecture of a portable computing device." EX1009, [0043].

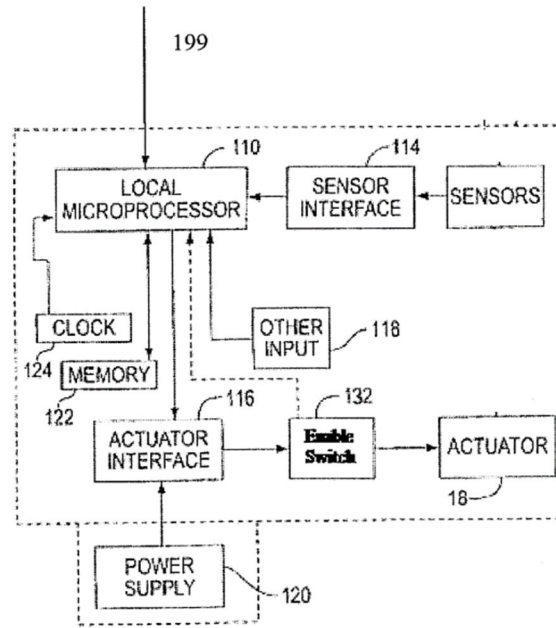


FIG. 3

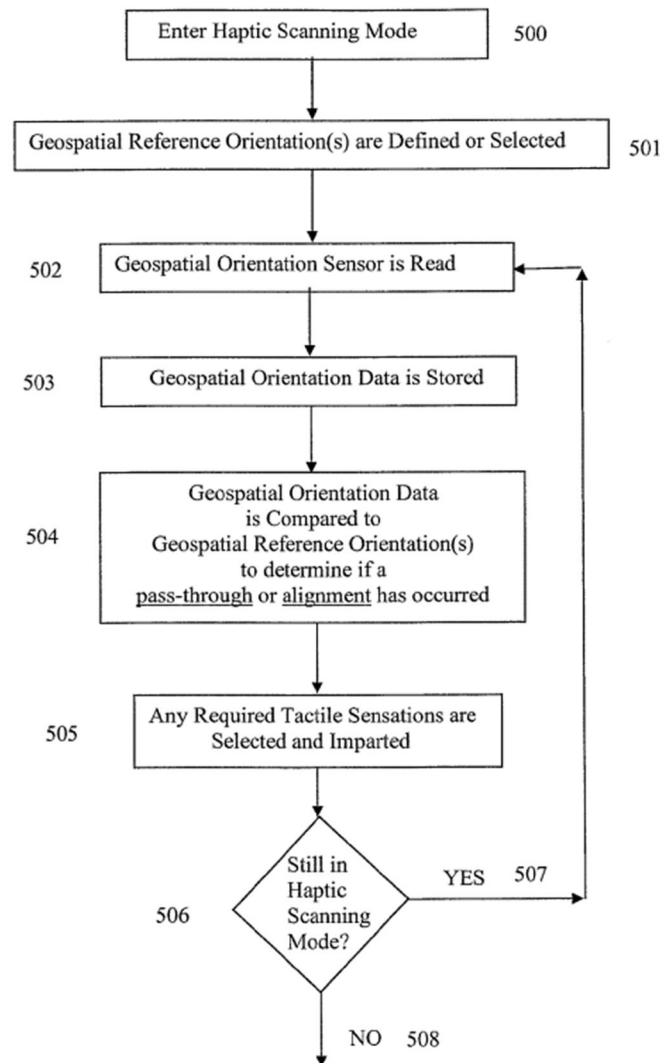
73. Rosenberg discloses the use of “processor controlled tactile feedback sensations,” and that its device includes “a computer processor disposed within the handheld casing.” EX1009, Abstract, claim 1. In the example shown in Figure 3, Rosenberg’s device includes a microprocessor that receives input signals from one or more sensor(s) and provides output signals to an actuator. EX1009, [0043]. The processor uses the input signals to determine what haptic feedback should be provided to a user. From the input signals, the processor maps an output command signal that can be sent to a haptic actuator to cause it to deliver the desired haptic feedback.

74. Suitable sensors include a “magnetometer[,],” which provides “orientational data” (e.g., an angle value between 0.0 and 360.0 degrees) to the processor. EX1009, [0043], [0076], [0023]-[0026]. Magnetometers are well-known sensors that are used (for example, in compasses) to determine a direction, exactly as described in Rosenberg.

75. Rosenberg lists (and incorporates by reference multiple other references that list) known actuators that create haptic sensations including vibrations. In short, Rosenberg teaches that its actuator can be any conventional haptic actuator that provides haptic or “tactile sensations” to users. EX1009, [0031]-[0038], [0046], [0054]. In this context, the phrase “tactile sensation” is synonymous with haptic sensation.

76. To map output commands from sensor input, the processor in Rosenberg’s device runs “software routines,” also called “Haptic Compassing Routines,” that “read one or more geospatial orientational sensors and in response to data received from the sensors, selectively impart an appropriate tactile cue upon the user at an appropriate time.” EX1009, [0033]; *see also* [0043], [0046]. I have reproduced Rosenberg’s Figure 5 below, which “illustrates a flowchart of software operations related to the Haptic Compassing Routines according to at least one embodiment of the invention.” EX1009, [0020], [0073].

FIG. 5



77. As the flowchart in Fig. 5 illustrates, the first step is for the device to enter a “Haptic Scanning Mode” at step 500. This is a mode in which the device provides haptic sensations to a user (if the user does not wish to receive haptic sensations, the device can be made to exit the Haptic Scanning Mode). EX1009, [0013].

78. After entering the Haptic Scanning Mode, a geospatial reference orientation (e.g., North) is selected (step 501) as the orientation the user would like to find. EX1009, [0073]-[0075]. At step 502, the device's processor then reads the geospatial orientation sensors to obtain geospatial orientation data indicating the device's current orientation. "One common form of the data is as angle value from 0.0 degrees to 360.0 degrees such that the angular value represents the clockwise angle away from NORTH." EX1009, [0076]. The orientation data, stored in memory (step 503), are compared to the desired reference orientation (step 504) "to determine if a tactile sensation is to be produced," e.g., when the device is aligned with, or passes through, the reference orientation. [0077].

79. Rosenberg discloses several ways that geospatial orientation data can be mapped to haptic effects. One technique, which I will refer to as "pass-through," creates a haptic effect when a user causes the compass to pass through an orientation of interest—i.e., it starts on one side of that orientation and moves past the orientation to the other side of it. EX1009, [0062]. Another technique, which I will refer to as "alignment," creates a haptic effect when the compass is aligned with (or substantially aligned with, e.g., within two degrees of) a reference orientation for a threshold amount of time. EX1009, [0064]. Haptic magnitude can also increase (or decrease) based on how long alignment with a reference orientation is maintained. EX1009, [0049], [0067].

80. Rosenberg also discloses another technique, referred to as “Variable Magnitude Alignment Sensation,” that causes a haptic effect when the compass is oriented within 10 degrees of a reference orientation, and increases the effect’s magnitude as the compass’s orientation gets closer to the reference orientation. EX1009, [0069]. Rosenberg also discloses a “Variable Frequency Alignment Sensation” that is similar except that the haptic effect’s frequency, rather than its magnitude, varies depending on angular proximity to the reference orientation. EX1009, [0070]-[0071]. These embodiments allow a user to “hone in” on a desired reference orientation because they provide real-time feedback (in the form of increasing or decreasing haptic magnitude or frequency) as the user moves the compass. EX1009, [0068], [0070]. Rosenberg also discloses further embodiments in which both magnitude and frequency of a haptic effect are varied based on alignment proximity. EX1009, [0072].

81. Based on my review, I conclude that Rosenberg meets every limitation of claim 1, thus anticipating claim 1. In my analysis below, I will explain how I arrived at this conclusion.

2. Claim 1

- a. **[1PRE]: “A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:”**

82. I understand that claim preambles do not always act as claim limitations. For purposes of my analysis, I assume that the preambles of all the independent claims challenged in the Petition, including claim 1, are limiting, and thus I evaluated whether the prior art discloses the preambles.

83. Rosenberg meets [1PRE]. As discussed below, Rosenberg’s device has a processor and memory which qualifies as a “non-transitory computer-readable medium.” Rosenberg’s memory stores instructions that, when executed by the processor, cause the processor to generate a haptic effect; as discussed in further detail below for other claim limitations, and the processor maps sensor input to an output haptic signal that causes an actuator to create a haptic effect. With that summary in mind, I will walk through individual disclosures in Rosenberg that show how Rosenberg discloses the preamble of claim 1.

84. Rosenberg discloses that its device has “local memory 122, such as RAM and/or ROM... coupled to microprocessor 110 to store instructions for microprocessor 110 and... temporary and other data.” EX1009, [0051]. *See also* Fig. 3, [0060], [0076]-[0078], claim 22 (“memory coupled to the processor”). A

“computer-readable medium” is just another way of referring to computer memory. “Non-transitory” computer memory, as opposed to “transitory” computer memory, generally refers to memory that retains data for more than a very brief period of time. The phrase “non-transitory” is commonly used to describe both Read Only Memory (ROM), in which data usually survive even when power to the memory is turned off, and Random Access Memory (RAM), which can usually retain data for lengthy periods of time, but only when power to the memory is turned on. I note that RAM and ROM are among the numerous examples of memory provided in the ’546 patent itself. EX1001, 2:55-59, 3:2-7. There is no suggestion in the ’546 patent that the claimed “non-transitory computer-readable medium” would exclude either RAM or ROM, or for that matter any of the other types of memory listed in the ’546 patent specification. Accordingly, Rosenberg’s memory 122, which can be RAM or ROM, is a “*non-transitory computer-readable medium having instructions stored thereon,*” as claimed.

85. Rosenberg’s device includes “microprocessor 110.” EX1009, [0051], Fig. 3; *see also* [0050] (“microprocessor 110 can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions”), [0062] (“software running upon the microprocessor”), [0064] (same), claim 22 (“memory coupled to the processor”). According to Rosenberg’s disclosures,

therefore, microprocessor 110 is a “*processor*” that “*execute[s]*” “*instructions*” stored in Rosenberg’s memory, as recited in [1PRE].

86. Rosenberg says that its processor executes “software routines that read orientational data from one or more geospatial sensors on board the portable computing device 100 and in response to changes in the data command a tactile sensation upon the user that corresponds with one or more geospatial orientations...called Haptic Compassing Routines.” EX1009, [0033]; *see also* [0043], [0050] (“microprocessor 110 can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions”). The “Haptic Compassing Routines” are used to “selectively activate[]” “haptic actuators” so the “user feels a tactile sensation.” EX1009, [0034]; *see also* [0043] (“processor 110 is configured to...provide signals to actuator 18 in accordance with the Haptic Compassing Routines”), [0046] (“under the control of the Haptic Compassing Routines, processor 110 is operative to selectively control one or more actuators 18 by sending a haptic control signal to actuator electronics 116”), [0062] (“software running upon the microprocessor...may be configured to control the actuator (or actuators) to impart a sensation upon the user”), [0073]-[0079], Fig. 3, Abstract (“processor controlled tactile feedback sensations”).

87. Given these disclosures, in my opinion Rosenberg’s Haptic Compassing Routines are “*instructions*” that, when executed by processor 110,

cause it to generate (by commanding an actuator) “haptic sensations” (EX1009, [0006], [0012]-[0013], [0028], [0032]-[0034], [0050]), i.e., a “*haptic effect*,” as claimed. The Haptic Compassing Routines are stored in Rosenberg’s memory, as claimed. EX1009, [0051], [0060]. For example, Rosenberg discloses that “the Haptic Compassing Routines select and/or define one of a plurality of possible tactile sensations based upon a particular type of geospatial orientation reference that has been encountered and/or how it has been encountered,” and “different types of tactile sensations may be associated in memory and/or algorithmically with Cardinal Directions”. EX1009, [0060]. Similarly, the same paragraph enumerates that:

[D]ifferent ones of the Cardinal Directions may be associated in memory and/or algorithmically with different tactile sensations. For example NORTH and SOUTH may be associated with one type of tactile sensation while EAST and WEST may be associated with a different type of tactile sensation. Similarly, different ones of the Intermediate Incremental Directions may be associated in memory and/or algorithmically with different tactile sensations. For example Intermediate Incremental Directions located at 15 degree intervals may be associated with one type of tactile sensation Intermediate Incremental Directions located at 5 degree intervals may be associated with a different type of tactile sensations.

EX1009, [0060]. Also, paragraph [0051] explains that “force profiles can be stored in memory 122, such as a sequence of stored force values that can be

output by the microprocessor to the actuator, or a look-up table of force values to be output to the actuator based on whether or not the portable computing device passes through and/or is aligned with a Cardinal Direction and/or with an Intermediate Incremental Direction and/or with a Target Direction.” EX1009, [0051]. In summary, it is clear to a POSA that the instructions for generating haptic effects are stored in Rosenberg’s memory, which matches claim 1’s preamble.

- b. [1A]: “receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;”**

88. Rosenberg meets [1A]. To begin with, Rosenberg’s processor “receive[s] signals from sensor 112,” which it uses to produce actuator command signals. EX1009, [0043], Fig. 3; *see also* [0046] (“Under the control of the Haptic Compassing Routines, processor 110 is operative to read orientational data from sensors 112.”), [0076] (“the geospatial orientation sensors on board the portable computing device...[are] read by the processor”), Fig. 5 (step 502). These disclosures show that Rosenberg’s processor receives input from Rosenberg’s sensor.

89. Rosenberg’s sensor 112 “may be, for example, one [] magnetometer[]” and can “provide orientational data with respect to the physical

world.” [0043]; *see also* [0023]-[0026], [0039], [0076], claim 1 (“an orientation determination component disposed within the handheld casing to determine a current geospatial pointing orientation of the casing of the portable navigation device”), claim 2 (“the orientation determination component comprises a magnetometer”). Rosenberg also describes specific products that can implement such a sensor. For example, the sensor can be a “basic HMR3100 two-axis electronic compass” offered by Honeywell for “a low cost, 19 mm by 19 mm daughter-board module for basic heading measurements,” or a “HMR3300 Digital Compass Solution [which] is a module featuring three-axis compassing with an onboard MEMs accelerometer for ± 60 degree tilt sensing and up to 1 degree accuracy and 0.1 degree resolution.” EX1009, [0026]. These further disclosures reinforce that Rosenberg’s processor “*receiv[es] input from a sensor,*” as claimed.

90. In my opinion the “orientational data” that Rosenberg’s processor receives from its sensor comprise the claimed “extra-sensory information.” Rosenberg discloses that the “orientational data” are the output of a magnetometer that detects orientation with respect to “the earth’s magnetic field” (EX1009, [0023]-[0026], [0076]), which cannot normally be perceived by a human being. Therefore, the “orientational data” output from the sensor will, in turn, include information that cannot normally be perceived by a human being. The reason compasses exist is that human beings are incapable of perceiving the earth’s

magnetic field and determining geospatial orientation. Indeed, the '546 patent itself explains that “extra-sensory information is information that cannot normally be perceived by a human being, such as an electromagnetic field,” EX1001, 2:13-20, and identifies “a magnetometer configured to detect electromagnetic fields” as a sensor “configured to detect extra-sensory information.” EX1001, 6:40-45; *see also* EX1001, 7:30-31, 8:23-31, 9:18-19, 10:35-42, 15:23-25, 16:19-23.

A magnetometer that detects orientation with respect to the earth’s magnetic field is a magnetometer configured to detect electromagnetic fields (the term “electromagnetic field” encompasses both magnetic fields and electric fields).

91. The “orientational data” (or “orientation data”—Rosenberg uses the two phrases interchangeably, *see, e.g.*, EX1009, [0026], [0046]) that processor 110 receives from sensor 112 also comprise the claimed “*one or more interaction parameters*.” Orientational data are parameters that are based on a user’s interaction with a device; the orientation of the device depends on the direction in which the user chooses to point it.

92. The New Oxford American Dictionary (from before the '546 patent application was filed) defines “parameter” as “a numerical or other measurable factor forming one of a set that defines a system or sets the conditions of its operation.” EX1015. The American Heritage Dictionary of the English Language (from before the '546 patent application was filed) defines “parameter” as “[o]ne

of a set of measurable factors, such as temperature and pressure, that define a system and determine its behavior.” EX1016. In summary, based on these two definitions and my own knowledge, a “parameter” as that term is used in the ’546 patent is a measurable factor that helps define a system’s behavior or operation. Rosenberg’s orientation angle is a good example of a “parameter” because it impacts the haptic sensation output to a user.

93. As to “interaction parameter,” I note that the ’546 patent never defines this phrase. I have reviewed EX1017, which I understand is a Final Written Decision for IPR2016-01372, involving another patent owned by the Patent Owner. I see that in that proceeding, the Patent Owner agreed that an interaction parameter is simply a parameter that is “based on a user’s interaction with a device.” EX1017, 7. Putting the two concepts together, an “interaction” parameter is a measurable factor, based on a user’s interaction with a device, that helps define a system’s behavior or operation.

94. Rosenberg’s “orientational data” include “an angle A that indicates the clockwise rotary orientation in degrees away from geographic NORTH,” toward which the device points. EX1009, [0076]. Angle A is a measurable factor that helps define the device’s haptic behavior (i.e., a “*parameter*” as claimed) because it impacts whether and how the device will produce a haptic effect. The value of Angle A depends on a user’s interaction with the device, i.e., in what

direction she “aimed [it] at the moment the data was read by the processor.”

EX1009, [0076]; *see also* EX1009, Abstract (“a user may perform a manual scanning operation wherein they manipulate the portable navigation device through a range of physical orientations and find a desired geospatial target orientation based upon their sense of touch”), [0013], claim 17 (“a handheld casing to be pointed in a direction by a user...repeatedly determining a current geospatial pointing orientation...”). The “orientational data” (angle value), i.e., the claimed “*input from a sensor,*” thus comprise “*one or more interaction parameters,*” as claimed. Further, Angle A can be any “angle value from 0.0 degrees to 360.0 degrees.” EX1009, [0076]. Angle values are “values” measured in degrees. Therefore, in my opinion Angle A also “*comprises a value,*” as claimed.

c. [1B]: “mapping the received input to a haptic signal; and”

95. Rosenberg meets [1B]. Rosenberg explains that “portable computing device 100 is equipped with one or more haptic actuators.” EX1009, [0032]. As already noted above, Rosenberg lists (and incorporates by reference multiple other references that list) actuators that create haptic sensations including vibrations. In short, Rosenberg teaches that its actuator can be any conventional haptic actuator that provides haptic or “tactile sensations” to users. For example, I note that Rosenberg’s paragraphs [0033]-[0038] describe different suitable haptic actuators “that may be incorporated into the casing of the portable computing device.” *See*

also EX1009, [0050]-[0052], [0060], [0062], [0064], Fig. 3. The haptic actuators provide “tactile sensations” to users, including “vibrations, a single jolt, or a texture sensation.” EX1009, [0050].

96. Rosenberg teaches that its haptic actuators are controlled by command signals sent from the processor to the actuators. For example, “[r]outines running upon the processor...select and impart sensations by sending appropriate signals...to one or more actuators within the portable computing device.” EX1009, [0033]; *see also* [0043] (“processor 110 is configured to...provide signals to actuator 18 in accordance with the Haptic Compassing Routines.”), [0046] (“[U]nder the control of the Haptic Compassing Routines, processor 110 is operative to selectively control one or more actuators 18 by sending a haptic control signal to actuator electronics 116....Based upon the timing and form of haptic control signals...tactile sensations are selectively produced”), [0052] (“force sensations [may] be sent by the microprocessor to the actuator”), [0054] (“Actuator 18 transmits forces to the housing of the portable computing device in response to signals received from microprocessor 110.”). In view of these disclosures, a POSA would therefore understand that Rosenberg’s “haptic control signals” are the claimed “*haptic signal*” recited in limitation [1B].

97. Furthermore, Rosenberg’s haptic control signals are mapped from the “*received input*,” as claimed. For example, Rosenberg at [0050] states that “[t]he

microprocessor 110 can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions.” EX1009, [0050]. *See also* EX1009, [0033].

98. Rosenberg discloses various ways that its processor maps “*received input*” (i.e., orientation data) to “*haptic signals*.” In my opinion these disclosed embodiments all meet limitation [1B]. Rosenberg even repeatedly uses the word “mapping” when describing how sensor input is transformed to haptic signals for commanding actuators to cause haptic feedback. For example, when describing the “Variable Magnitude Alignment Sensation” embodiment, Rosenberg explains:

[T]actile sensation is not produced unless the portable computing device orientation comes within 10 degrees of the geospatial reference orientation (clockwise or counter clockwise). Once within that angular threshold, the magnitude of the sensation...increase[s] from 25% to 75% as an inversely linear function of angular proximity. Thus when the angular distance between the portable computing device orientation and the geospatial reference orientation is 10 degrees, the magnitude is 25%. And as the angular distance between the portable computing device orientation and the geospatial reference orientation goes to 0, the magnitude rises to 75%. The mapping can be linear. The mapping may also be non-linear.

EX1009, [0069]. *See also* EX1009, [0071] (describing “mapping” for “Variable Frequency Alignment Sensation” in which the haptic effect’s frequency, rather than its magnitude, varies). In these embodiments, a POSA would understand the

“*received input*” (i.e., orientation data or angle value indicating angular proximity to a reference orientation) is mapped to a “*haptic signal*” providing a sensation, the magnitude and/or frequency of which changes as the received sensor input changes.

99. Rosenberg’s “alignment” technique works in a similar fashion:

The software running upon the microprocessor...may be configured to control the actuator (or actuators) to impart a sensation upon the user when it is determined that a reference orientation within the portable computing device (or an aimable portion thereof) is...aligned (or substantially aligned) along a geospatial reference orientation...for more than some threshold amount of time....The range might be, for example, plus or minus two degrees of the reference orientation.

EX1009, [0064].

100. In Rosenberg, the particular haptic effect can be selected based on the direction with which the compass is aligned. For example, when using the “alignment” technique, Rosenberg provides examples of haptic effects as follows: alignment with a cardinal direction can cause a sinusoidal vibration of 80 HZ frequency, 2500 ms duration and 65% magnitude; alignment with an intermediate incremental direction (which are directions separated by 15 degree intervals) can cause a sinusoidal vibration of 60 HZ frequency, 1750 ms duration and 45% magnitude; and alignment with a target direction chosen by a user can cause a saw-tooth vibration of 95 HZ frequency, 3500 ms duration and 80% magnitude.

EX1009, [0064]. *See also* EX1009, [0060]. Therefore, a POSA would understand the “*received input*” (i.e., the angle value the processor evaluates for substantial alignment with a reference orientation for a threshold time period) is mapped to the “*haptic signal*” providing a haptic effect that depends on the angle value. EX1009, [0064].

101. In Rosenberg’s “pass-through” approach, a haptic effect is generated when the device passes through a reference orientation, i.e., it “begins on one side of the geospatial reference orientation and moves to the other side.” EX1009, [0062]. The particular haptic effect can be selected based on the passed-through direction. EX1009, [0060], [0062]. For instance, passing through a cardinal direction can result in sinusoidal vibration of frequency 80 HZ, 320 ms duration and 45% magnitude; passing through an intermediate incremental direction can cause a sinusoidal vibration of frequency 60 HZ, 180 ms duration and 30% magnitude; and passing through a target direction chosen by a user can cause a saw-tooth vibration of frequency 95 HZ, 500 ms duration and 60% magnitude. EX1009, [0062]. Thus, a POSA would understand the “*received input*” (i.e., the angle value the processor evaluates for pass-through) is mapped to the “*haptic signal*” providing a haptic effect that depends on the angle value.

102. In view of the above, in my opinion Rosenberg’s processor generates haptic feedback by “*mapping the received input to a haptic signal,*” as claimed.

d. [1C]: “sending the haptic signal to an actuator to generate the haptic effect;”

103. Rosenberg meets [1C]. Rosenberg discloses that its “portable computing device 100 is equipped with one more haptic actuators,” which a POSA would understand is intended to mean “equipped with one or more haptic actuators.” EX1009, [0032]. *See also* EX1009, [0033]-[0038], [0036], which describe that the actuator can take a variety of forms, including an “electro-active polymer and/or piezoceramic.” Rosenberg’s haptic actuators provide “tactile sensations” to users, including “vibrations, a single jolt, or a texture sensation.” EX1009, [0050]. Rosenberg also teaches that “electronically controlled tactile sensations” (which would include the tactile sensations provided by Rosenberg’s haptic actuators) is referred to as a “haptic sensation[],” EX1009, [0006], and that “the term ‘tactile sensation’ refers to [] a haptic sensation [provided] to the user.” EX1009, [0050]. A sensation is an effect felt by the body. A POSA would therefore understand that Rosenberg’s “tactile sensations” include a “*haptic effect*,” as claimed. I note also that the ‘546 patent also describes that “haptic effect” encompasses “tactile” feedback and “an effect that produces a vibration.” EX1001, 1:11-14, 2:29-41.

104. Rosenberg’s processor sends a haptic command signal to the device’s actuators to produce tactile sensations. For example: “Also, the local memory can store predetermined force sensations to be sent by the microprocessor to the

actuator (or actuators) aboard the portable computing device.” EX1009, [0052]. Likewise: “Actuator 18 transmits forces to the housing of the portable computing device in response to signals received from microprocessor 110.” EX1009, [0054]. *See also* EX1009, [0051] (noting that “a sequence of stored force values...can be output by the microprocessor to the actuator”), [0033], [0043] (“processor 110 is configured to receive signals from sensor 112 and provide signals to actuator 18 in accordance with the Haptic Compassing Routines”), [0050], [0054], [0062], [0064]. As I explained in the preceding section about limitation [1B], Rosenberg’s command signal, sometimes referred to in Rosenberg as a “haptic control signal,” is the claimed “haptic signal.” EX1009, [0046]. A POSA would understand that Rosenberg’s processor generates haptic feedback by “*sending the haptic signal to an actuator to generate the haptic effect,*” as claimed.

105. I note that while Figure 3 of Rosenberg illustrates an “actuator interface 116” and an “[e]nable switch 132” between the arrows that flow from local microprocessor 110 to actuator 18, they are both described as “optional” and not required. EX1009, [0055] (“[a]ctuator interface 116 can be optionally connected between actuator 18 and microprocessor 110 to convert signals from microprocessor 110 into signals appropriate to drive actuator 18”); [0058] (“Enable switch 132 can optionally be included”). For all the reasons described above, including the disclosures cited in the preceding paragraph, Rosenberg discloses to

a POSA having its processor send a haptic control signal directly to actuator 18 to generate a haptic effect without an intervening component.

106. Moreover, even if Rosenberg's "optional" approach was used and its processor sent the signal to actuator interface 116 (EX1009, Fig. 3, [0055]) which was used "to convert signals from microprocessor 110 into signals appropriate to drive actuator 18," for example by using a "power amplifier[]" (EX1009, [0055]), a POSA would still consider this to satisfy the language "*sending the signal to an actuator to generate the haptic effect*," as claimed. For example, paragraph [0033] of Rosenberg states, "Routines running upon the processor of the portable computing device select and impart sensations by sending appropriate signals, through power amplifier electronics, to one or more actuators within the portable computing device." Thus, Rosenberg itself describes sending signals "through" a component such as a power amplifier, to still be "sending appropriate signals...to one or more actuators." It would be overly formalistic (and contrary to Rosenberg's description and contrary to a POSA's understanding) to suggest that amplifying or otherwise conditioning a signal sent by the processor before it reaches the actuator somehow negates that the signal was sent by the processor to the actuator. Indeed, a POSA would understand that such signal conditioning is very common, and related to various design choices and the associated tradeoffs such as power, size, weight, and cost.

- e. **[1D]: “the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input;”**

107. I understand from counsel that there are two potential constructions for the phrase “*modulating the haptic signal when new input is received*” in limitation [1D]: a first potential construction which would require continuously mapping successive sensor inputs, one after the other, to modulated haptic signals; and a second potential construction which would not require that the “new input” mapping to the modulated haptic signal be received immediately after earlier input that was mapped to a haptic signal. I understand that under the second potential construction, claim 1 would be broad enough to cover a scenario in which one sensor input is mapped to a haptic signal, after which, for some period of time, new/updated sensor inputs are not mapped to any haptic signal, after which a new/updated sensor input is mapped to a modulated haptic signal. I have been asked to consider whether the four embodiments of Rosenberg (which I refer to as the “Variable Magnitude Alignment Sensation,” “Variable Frequency Alignment Sensation,” “pass-through” and “alignment” embodiments) would meet or render obvious limitation [1D] under each of the two potential constructions.

108. As an initial matter, Rosenberg describes that its processor receives “repeated data samples of the sensor...at a rapid rate.” EX1009, [0080]. In [0033],

Rosenberg describes that “the routines running upon the processor of the portable computing device repeatedly reads one or more geospatial orientational sensors, such as a digital compass module, and determines based upon the repeated data accessed that the portable computing device (or a portion thereof) has just crossed and/or has just aligned with an orientation corresponding with geographic NORTH.” By virtue of its reference to using sensor data to determine whether the compass “has just crossed and/or has just aligned with an orientation,” a POSA would understand that this paragraph refers to both the “alignment” and “pass-through” embodiments. It would make sense to a POSA that the device “repeatedly reads” the sensors in those embodiments because the processor needs updated sensor input to determine whether a pass-through or an alignment condition has occurred.

109. Furthermore, in [0068]-[0070], Rosenberg describes that tactile sensations can change to “allow[] the user to sweep the device around and hone in” upon a reference orientation. This “honing-in” functionality also requires repeated sampling of the sensed orientation over time because as users “sweep the device around,” the “angular distance” between the sensed orientation and the reference orientation changes with time, as does the *rate* of angular change, and the changing angle is what dictates the changing haptic sensation provided to the user. EX1009, [0068]-[0071]. Rosenberg explains how the repeated sampling is implemented.

EX1009, [0086] (explaining that software repeats steps 502 to 505 in Figure 5), claim 17 (“repeatedly determining a current...orientation”). Rosenberg’s processor 110 thus receives updated orientation data from sensor 112, including an updated “angle value” based on repeated sensor sampling. EX1009, [0076]. As I explained above regarding limitation [1A], the updated angle value is an “*interaction parameter*” with a “*value*.” Therefore, in all of the embodiments under consideration, Rosenberg’s processor receives “*new received input*” that “*comprises an update of at least one value of at least one interaction parameter of the received input,*” as claimed.

110. Rosenberg’s “Variable Magnitude Alignment Sensation” and “Variable Frequency Alignment Sensation” embodiments both satisfy the phrase “*modulating the haptic signal when new input is received*” under the first potential construction thereof. In the context of the ’546 patent, modulating something simply means to control or adjust it, e.g., in the case of a haptic effect, by changing the effect’s magnitude and/or frequency (a POSA would understand that when speaking about the signal that causes an actuator to produce a haptic effect, if the *haptic effect* is modulated then the *signal* that causes the effect must also be modulated). In both the “Variable Magnitude Alignment Sensation” and “Variable Frequency Alignment Sensation” embodiments, once users point the compass within 10° of a reference orientation, the haptic effect’s magnitude or frequency

increases as “the angular proximity of the geospatial reference orientation...is reduced,” i.e., as the compass points closer to the reference orientation. EX1009, [0068]-[0071]. The changing magnitude or frequency “allows the user to sweep the device around and hone in upon the active reference orientation.” EX1009, [0068], [0070]. These embodiments meet “*modulating the haptic signal when new input is received*” under the first potential construction because, as users point the compass closer to a reference orientation (each new angle value being “*new input*” the processor receives from the sensor as a user points the compass closer to or farther from a reference orientation, e.g., within ten degrees of the reference orientation), the haptic effect is continuously modulated (i.e., its magnitude and/or frequency change continuously based on each successive new sensor input). In other words, a POSA would understand that in both these embodiments the haptic signal that produces the haptic effect is also continuously modulated based on each successive new sensor input. Indeed, I note that both embodiments involve continuous mathematical transformations of successive sensor inputs into haptic signals, just as the ’546 patent specification describes. EX1009, [0069] (“The mapping can be linear. The mapping may also be non-linear.”); [0071] (same). The “linear” or “non-linear” mappings refer to mathematical transformation of each input value received from a sensor (x) into a corresponding output value Y with a mathematical function $Y = f(x)$, where $f(x)$ can be a linear function or a non-

linear function. Once Rosenberg's compass is within 10° of a reference orientation, a haptic control signal is continuously modulated from sensor inputs according to such mapping, EX1009, [0069], [0071], allowing the user to "sweep the device around and hone in upon the active reference orientation." EX1009, [0068], [0070]. Accordingly, in my opinion both of the "Variable Magnitude Alignment Sensation" and "Variable Frequency Alignment Sensation" embodiments satisfy limitation [1D] under the first potential construction of *"modulating the haptic signal when new input is received."*

111. Because Rosenberg's "Variable Magnitude Alignment Sensation" and "Variable Frequency Alignment Sensation" embodiments meet limitation [1D] under the first potential construction, requiring continuous modulation of the haptic signal, they also, *a fortiori*, also meet limitation [1D] under the second potential construction, which I understand does not require that a first haptic signal and a second haptic signal (modulated relative to the first haptic signal) result from mappings based on successive sensor inputs received from the sensor one immediately after the other.

112. The remaining two embodiments I considered (Rosenberg's "pass-through" embodiment and "alignment" embodiment) satisfy limitation [1D] under the second potential construction, and render limitation [1D] obvious under the first potential construction.

113. In the “pass-through” embodiment, a haptic effect is generated when new sensor input (orientation angle), compared to prior input, shows the device passed through a reference orientation. EX1009, [0062]. The haptic effect’s magnitude, frequency and duration depends on the passed-through direction. EX1009, [0062]. If a new input later shows that the device passed through a second direction, the haptic effect will be different as I mentioned above; in other words, the haptic effect will be modulated relative to the earlier haptic effect that resulted from the compass passing-through a first direction. EX1009, [0062]. The haptic signal—which causes the haptic effect—will also be modulated, thus satisfying limitation [1D] under the second potential construction, which I understand does not require continuous modulation of the haptic signal for successive sensor inputs. While some period of time presumably would pass between the first pass-through event and the second pass-through event, such that some sensor inputs would be received by the processor between those two events without leading to any haptic effects, this would not detract from satisfaction of limitation [1D] under the second potential construction which does not require continuous modulation. As I understand from counsel, under the second potential construction it is enough, to satisfy limitation [1D], for one sensor input to be mapped to a first haptic signal, after which, at a later time (including after other sensor inputs have been received which were not mapped to any haptic signals), a

new/updated sensor input is received that is mapped to second haptic signal that is different from the first haptic signal, hence representing a modulation of the haptic signal.

114. Under the first potential construction of “*modulating the haptic signal when new input is received*,” Rosenberg’s “pass-through” embodiment would still render [1D] obvious. Some sensor inputs indicate that a pass-through has occurred; others do not. There are just two approaches to the latter type of input: either no haptic signal is sent to the actuator (such that no haptic effect will be produced), or the input is mapped to a haptic signal instructing the actuator to do nothing (such that, again, no haptic effect will be produced). Both approaches would be obvious, but a POSA would recognize the latter’s simplicity since all inputs would map to haptic signals. In other words, it would be simple for the processor to always issue an instruction to the actuator every time a sensor input is received by the processor (even if the instruction is, sometimes, that the actuator should produce no haptic effect at all). For example, one of the simplest programming constructs to implement such an algorithm would be to use a single loop function comprising the following (in pseudo code): void loop() {X = Read_Sensor(); Y = Function(X); Output_to_Actuator(Y);}. The Function(X) can be implemented as a look-up table, or a conditional function that maps different types of haptic signal Y to different sensor inputs X. Such a Function(X) can be a

mathematical transformation expressible, e.g., as a piecewise function, for example a look-up table that maps the input X to discrete samples of a mathematical transformation to Y. I note that Rosenberg expressly describes “a look-up table of force values to be output to the actuator based on whether or not the portable computing device passes through and/or is aligned with a Cardinal Direction.” EX1009, [0051]. It would be obvious to use Rosenberg’s look-up table to list both types of signals (i.e., signals instructing the actuator to produce various different haptic effects, examples of which are listed in Rosenberg, and a signal instructing the actuator not to produce any haptic effect). The two types of haptic signals—one instructing the actuator to create a haptic effect, another instructing the actuator to do nothing, mapped from successive sensor inputs, would be “modulated” relative to one another, thus satisfying limitation [1D] under the narrower potential interpretation. The resulting haptic effects mapped from successive sensor inputs would also be modulated relative to one another. By way of example, one obvious scenario satisfying the narrower interpretation would be if a first sensor input indicates that a “pass-through” has occurred, and thus is mapped to a haptic signal instructing the actuator to produce a haptic effect, and the next sensor input, which does not indicate that another pass-through (or any other haptic effect-producing event) has occurred is mapped to a haptic signal instructing the actuator to do nothing. The latter haptic signal is “modulated”

relative to the former haptic signal since doing nothing is different from producing a haptic effect.

115. In the “alignment” embodiment, “current and historical sensor values”—the “current” one a “*new input*” as claimed—are used to determine if a device “is aligned (or substantially aligned) with a geospatial reference orientation for more than the threshold amount of time.” EX1009, [0064]. If so, a haptic effect is generated which depends on direction. EX1009, [0064]. If new sensor input later shows the compass is aligned with a different direction, the haptic effect is modulated. EX1009, [0064]. The haptic signal—which causes the haptic effect—is also modulated, thus satisfying limitation [1D] under the second potential construction, which does not require continuous modulation of the haptic signal for successive sensor inputs as I explained above.

116. Under the first potential construction, Rosenberg’s “alignment” embodiment renders limitation [1D] obvious for the same reasons as the “pass-through” embodiment. Some sensor inputs indicate alignment; others do not. There are just two approaches to the latter type of input: either no haptic signal is sent, or the input is mapped to a haptic signal instructing the actuator to do nothing, e.g., a current of 0. Both would be obvious, but a POSA would recognize the latter’s simplicity since *all* inputs would be mapped to haptic signals using e.g., a lookup table (as I explained above). The two types of haptic signals, mapped from

successive sensor inputs, would be “modulated” relative to one another, thus satisfying limitation [1D] under the narrower potential interpretation of “*modulating the haptic signal when new input is received.*” The resulting haptic effects mapped from successive sensor inputs would also be modulated relative to one another.

- f. **[1E]: “the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.”**

117. Rosenberg meets [1E]. As I explained above regarding limitation [1C], when executed by processor 110, the instructions stored in Rosenberg’s memory cause the processor to generate haptic feedback by “*sending the haptic signal to an actuator to generate the haptic effect,*” as claimed. I also explained above (regarding limitation [1D]) that the Variable Magnitude / Frequency Alignment Sensation embodiments satisfy “*modulating the haptic signal when new input is received*” under both potential constructions, and that the “pass-through” and “alignment” embodiments satisfy it under the second potential construction and render it obvious under the first potential construction. Because a POSA would understand that all of Rosenberg’s embodiments meet or render obvious “*modulating the haptic signal when new input is received*” in limitation [1D] they would also understand that all of Rosenberg’s embodiments modulate (or render

obvious modulating) the haptic effects accordingly (i.e. by changing the magnitude and/or frequency of the haptic effect).

118. For the same reasons a POSA would understand that all of Rosenberg's embodiments meet "*sending the haptic signal to an actuator to generate the haptic effect*" in limitation [1C] and "modulating the haptic signal when new input is received" in limitation [1D] (and hence they all also modulate the haptic effect as explained in the section above), a POSA would understand that all of Rosenberg's embodiments also meet limitation [1E]. *See e.g.* EX1009, [0052], [0033], [0043] ("processor 110 is configured to...provide signals to actuator 18 in accordance with the Haptic Compassing Routines."); *see also* [0046], [0050]-[0051], [0054]-[0055], [0058], [0062], [0064].

3. Claim 2: "The non-transitory computer-readable medium of claim 1, the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value."

119. Rosenberg meets claim 2 in multiple different ways. In Rosenberg's Variable Magnitude Alignment Sensation embodiment and the Variable Frequency Alignment Sensation embodiment, "the tactile sensation is not produced unless the portable computing device orientation comes within 10 degrees of the geospatial reference orientation (clockwise or counter clockwise)." EX1009, [0069], [0071]. The processor thus generates a haptic signal only when the angle value it receives

from sensor 112 is within 10 degrees of the geospatial reference orientation. The “angle value” is “from 0.0 degrees to 360.0 degrees,” representing “the clockwise angle away from NORTH.” EX1009, [0076]. If north is chosen as the reference orientation, and if the phrase “within 10 degrees” in [0069]-[0071] of Rosenberg excludes the lower endpoint of the range (i.e., 350.0°), then the processor generates a haptic signal when the device is oriented between 350.0° and 360.0°, i.e., when the angle value exceeds 350.0°. Alternatively, if the phrase “within 10 degrees” in [0069]-[0071] of Rosenberg includes the lower end point of the 10-degree range, the processor generates a haptic signal when the device is oriented when the angle (clockwise away from NORTH in this example) exceeds the next-highest discrete value lower than 350.0°, e.g., 349.9°. Similarly, if the reference orientation is 350.0°, the processor generates a haptic control signal when the device is oriented between 340.0° and 360.0°, i.e., when the angle value exceeds 340.0° (or, if the phrase “within 10 degrees” in [0069]-[0071] of Rosenberg includes the lower end point of the 10-degree range, when the angle exceeds the next-highest discrete value lower than 340.0°, e.g., 339.9°). Either way, the processor generates a haptic control signal when the angle value “exceeds” a value such as 350.0° or 349.9° or 340.0° or 339.9°. Accordingly, these embodiments satisfy claim 2.

120. In the “alignment” embodiment, the haptic signal is generated when the device is “within...plus or minus two degrees of the reference orientation” for

“more than some threshold amount of time.” [0064]. This satisfies claim 2 for the same reasons as the preceding embodiments. For example, if the reference orientation is 358.0°, the haptic signal is generated when the device is oriented between 356.0° and 360.0°, i.e., when the angle value exceeds 356.0° (or, if “within...two degrees” in [0064] of Rosenberg includes the lower end of the 2-degree range, the haptic signal is generated when the angle exceeds the next-highest discrete value lower than 356.0°, e.g., 355.9°). Either way, the processor generates a haptic control signal when the angle value “exceeds” a value such as 356.0° or 355.9°. Accordingly, the “alignment” embodiment satisfies claim 2.

121. In the “pass-through” embodiment, as discussed above, a haptic signal is generated when the device passes through a reference orientation. If the user is turning the device clockwise, the angle must increase beyond the reference orientation angle. For example, if the reference angle is 300°, the haptic signal will be generated when the angle exceeds 300°, thus satisfying claim 2.

4. Claim 3: “The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.”

122. Rosenberg meets claim 3. As I discussed for limitation [1C], Rosenberg’s “*actuator*” is a haptic actuator providing “tactile sensations” including vibrations. EX1009, [0050]; *see also* EX1009, [0032]-[0038].

123. Rosenberg discloses actuators that impart “inertially induced vibrations that are transmitted to the user through the casing of the portable computing device 100.” EX1009, [0034]; *see also* [0028], [0032] (“In many embodiments the actuators...induc[e] vibration forces”), [0034], [0049]-[0050], [0062]-[0064] (“pass-through” and “alignment” embodiments can provide sinusoidal or saw-tooth vibrations), [0069]-[0071] (Variable Magnitude / Frequency Alignment Sensation embodiments can provide sine wave vibrations), claims 1, 8 (“a haptic actuator...to provide...a vibration sensation”). Rosenberg thus discloses a “*vibration actuator*,” as claimed, which generates a “*vibration haptic effect*,” as claimed.

5. Claim 4: “The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a deformation actuator, and wherein the haptic effect generated by the deformation actuator comprises a deformation haptic effect.”

124. Rosenberg meets claim 4. Rosenberg discloses that its device provides a “tactile sensation” in each of the “alignment,” “pass-through,” Variable Magnitude Alignment Sensation, and Variable Frequency Alignment Sensation embodiments. EX1009, [0062], [0064], [0068]-[0072]. Rosenberg explains that “different types of actuators” are suitable. EX1009, [0036]. For example, “a surface of the portable computing device itself may be comprised of a electronically responsive material such as electro-active polymer [EAP] and/or

piezoceramic that can be controlled to produce tactile sensations felt by a user holding the device.” EX1009, [0036]; *see also* [0050]. Rosenberg thus discloses, among other options, using EAP to produce “tactile sensations” for all its embodiments. As I explained above, in Rosenberg, “tactile sensations” includes a haptic effect as claimed.

125. A POSA would have understood that, in an embodiment in which a surface of Rosenberg’s device comprises “electronically responsive material such as electro-active polymer and/or piezoceramic,” EX1009, [0036], that material constitutes a “*deformation actuator*,” as claimed. Indeed, I note that the ’546 patent itself identifies an “electroactive polymer (‘EAP’) actuator” as a deformation actuator. EX1001, 3:46 (’546 patent abbreviating “electroactive polymer” as “EAP”), 5:65-6:3 (“EAPs may be used to form one or more actuators...for shape changing”), 6:6-13 (“[P]atterns can then be applied to the flexible surface of device 300 using a deformation mechanism. A haptic substrate that includes a plurality of actuators can be applied to the surface to enact or form the patterns. EAPs, for example, can be employed...”). It was also known that an electro-active polymer actuator functions by deforming its shape or volume. *See, e.g.,* EX1018, 3 (active polymer “acting as the active functional unit, i.e., the actuator” can “change its volume by swelling or shrinking more than 90%”).

126. A POSA would also have understood that, in an embodiment in which a surface of Rosenberg’s device comprises EAP (i.e., a “*deformation actuator*”) “that can be controlled to produce tactile sensations felt by a user holding the device,” EX1009, [0036], such a tactile sensation constitutes a “*deformation haptic effect*” as claimed because the EAP-based actuator functions by deforming.

127. Further, Rosenberg itself explains that its “tactile sensation,” EX1009, [0036], [0062], [0064], [0068]-[0072], can be a “texture sensation.” EX1009, [0050] (“[V]ibrations, a single jolt, or a texture sensation are all considered tactile sensations.”). Texture sensation is a “*deformation haptic effect*,” as claimed. For example, the ’546 patent explains that a deformation actuator outputs a deformation haptic effect such as “a change in a texture of the haptic device,” EX1001, 6:8-13, 9:52-61, and that a “deformation haptic effect” includes changing “a texture of the device”, EX1001, 16:2-8. Also, claim 18 of the ’546 patent recites that a “deformation haptic effect” includes changing “a texture of the device.” Thus, Rosenberg’s disclosure of using “texture sensation” as a “tactile sensation” independently meets the “*deformation haptic effect*” claim language.

128. If Patent Owner contends, despite the above disclosures, that Rosenberg fails to explicitly disclose using a deformation actuator to produce deformation haptic effects, implementing Rosenberg with a deformation actuator to produce tactile/texture sensations ([0036], [0050]) would have been an obvious

combination of prior-art elements according to known methods to yield predictable results. The following summarizes some of these prior-art teachings.

129. For example, the Examiner during prosecution of the '546 patent's application cited multiple prior-art teachings in finding that deformation actuators that output deformation haptic effects were conventional in the prior art, and their use would "yield a predictable result," and the applicants did not dispute these findings. EX1002, 123-124 (examiner citing U.S. Publ. 2006/0103634 ("Kim," EX1010) as disclosing deformable haptic effects), 154 (applicants conceding that Kim discloses deformable EAP); *see also* EX1002, 120 (examiner citing U.S. Publ. 2009/0189746 ("Ullrich '746," EX1011) and U.S. Publ. 2010/0253525 ("Engel," EX1012) as disclosing deformation actuators), 124 (taking official notice that "the deformation haptic effect of a haptic simulation which having texture effect, for example, for skin sensation are well known in the art"). The '546 patent itself cites (EX1001, 6:30-33) another reference (EX1013, which I understand is prior art) as describing "[f]urther details of devices capable of producing shape changing or deformation haptic effects." *See also* EX1018. I agree with the Examiner that deformation actuators were known in the prior art, and were known to yield a predictable result. Accordingly, in my opinion, in addition to being anticipated by Rosenberg, claim 4 would have been obvious over Rosenberg in view of a POSA's knowledge about well-known deformation actuators.

6. Claim 5

130. Claim 5 recites a “*computer-implemented method for generating a haptic effect*” that comprises acts that claim 1’s “*instructions*” cause a processor to perform, namely the acts of:

receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;

mapping the received input to a haptic signal; and

sending the haptic signal to an actuator to generate the haptic effect;

the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and

the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.

131. As I explained above Rosenberg meets all of these limitations in claim

1. Therefore, Rosenberg meets claim 5 for the same reasons it meets claim 1.

7. Claim 6

132. Claim 6 depends from claim 5, and recites a “*computer-implemented method for generating a haptic effect*” that comprises acts that the “*instructions*” recited in claim 2 cause a processor to perform, namely the acts of:

the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value.

133. As I explained above Rosenberg meets all of the limitations of claims 2 and 5. Rosenberg meets claim 6 for the same reasons it meets claims 2 and 5.

8. Claim 7

134. Claim 7 depends from claim 5, and recites “wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.” Claim 7 limits claim 5’s method to one used with the vibration actuator of claim 3.

135. As I explained above Rosenberg meets all of the limitations of claims 3 and 5. Rosenberg meets claim 7 for the same reasons it meets claims 3 and 5.

9. Claim 8

136. Claim 8 depends from claim 5, and recites “wherein the actuator comprises a deformation actuator, and wherein the haptic effect generated by the

deformation actuator comprises a deformation haptic effect.” Claim 8 limits claim 5’s method to one used with the deformation actuator of claim 4.

137. As I explained above Rosenberg meets all of the limitations of claim 5 and meets or renders obvious the limitations of claim 4. Accordingly, Rosenberg (or an obvious implementation of its teachings) meets or renders obvious claim 8 for the same reasons it meets or renders obvious claims 4 and 5.

10. Claim 9

a. [9PRE]: “A haptic representation system comprising:”

138. Rosenberg meets [9PRE]. Rosenberg discloses a “portable computing device” with a “geospatial haptic compass” that allows the device to provide “tactile feedback to a user corresponding to a direction of orientation of the portable computing device.” EX1009, [0002]; *see also* EX1009, [0007].

Rosenberg explains that “portable computing device 100 is equipped with one more haptic actuators,” which a POSA would understand is intended to mean “equipped with one or more haptic actuators.” EX1009, [0032]; *see also* EX1009, [0033]-[0038] (describing different suitable actuators), EX1009, [0036] (actuator can be an EAP). The haptic actuators provide “tactile sensations” that include “vibrations, a single jolt, or a texture sensation.” EX1009, [0050].

139. I have reproduced below Figure 1 of Rosenberg, which shows an exemplary portable computing device. I have also reproduced Figure 3 of

Rosenberg, which shows a “computational architecture of a portable computing device” including one or more sensors, processor, and actuator. EX1009, [0043].

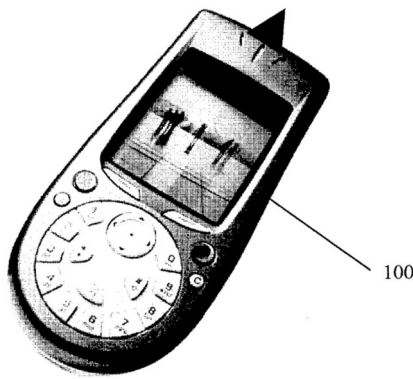


FIG. 1

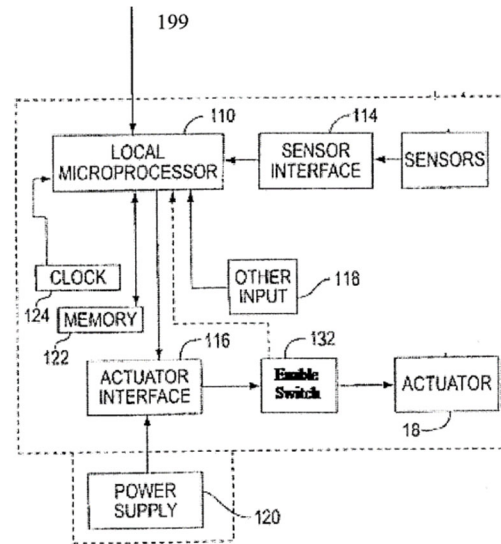


FIG. 3

140. The '546 patent explains that its Figure 1 depicts “a haptic representation system.” EX1009, 1:40-41. The haptic representation system of Figure 1 in the '546 patent includes components such as a sensor, a processor and an actuator. The '546 patent explains that the role of the “haptic representation system” is to “represent the sensor input as haptic output.” EX1001, 4:16-19. Rosenberg’s device represents geospatial sensor input as haptic output as discussed above, and to do so it uses the components that match the key components of the '546 patent’s “haptic representation system”—e.g., sensor, processor, and

actuator. EX1009, Fig. 3. Rosenberg thus includes a “*haptic representation system*,” as claimed.

b. [9A]: “a memory configured to store a haptic representation module;”

141. Rosenberg meets [9A]. First, Rosenberg discloses a “*memory*.” As I discussed regarding limitation [1PRE], Rosenberg’s device includes “local memory 122...coupled to microprocessor 110 to store instructions for microprocessor 110 and store temporary and other data.” EX1009, [0051]; *see also* Fig. 3, [0060], [0076]-[0078]; claim 22 (“memory coupled to the processor”). Local memory 122 is thus a “*memory*,” as claimed.

142. Second, Rosenberg also discloses a “*haptic representation module*.” Initially, I note that the ’546 patent explains that a “haptic representation module” is “software” that “generates a haptic effect that represents received input.” EX1001, 3:8-15.

143. Rosenberg also discloses software that generates a haptic effect that represents received input. That is the function of Rosenberg’s Haptic Compassing Routine software, discussed previously. *See also* EX1009, [0033] (“[T]he software routines that read orientational data from one or more geospatial sensors on board the portable computing device 100 and in response to changes in the data command a tactile sensation upon the user that corresponds with one or more geospatial orientations, are called Haptic Compassing Routines.”), [0034] (“Haptic

Compassing Routines” are used to “selectively activate[]” actuators so the “user feels a tactile sensation”), EX1009, [0046] (“under the control of the Haptic Compassing Routines, processor 110 is operative to selectively control one or more actuators 18 by sending a haptic control signal to actuator electronics 116”), EX1009, [0062], [0073]-[0079], Fig. 5. Rosenberg’s Haptic Compassing Routine software thus is a “*haptic representation module*” as claimed.

144. Rosenberg’s Haptic Compassing Routines are stored in Rosenberg’s memory. [0051], [0060]. For example, Rosenberg discloses that “the Haptic Compassing Routines select [] one of a plurality of possible tactile sensations based upon a particular type of geospatial orientation reference that has been encountered and/or how it has been encountered,” and “[f]or example, different types of tactile sensations may be associated in memory and/or algorithmically with Cardinal Directions....Similarly, different ones of the Intermediate Incremental Directions may be associated in memory and/or algorithmically with different tactile sensations.”). EX1009, [0060].

145. Thus, Rosenberg’s memory is “*configured to store a haptic representation module*,” as claimed.

c. [9B]: “a processor configured to execute the haptic representation module stored on the memory;”

146. As I discussed regarding limitation [1PRE], Rosenberg’s device includes “microprocessor 110.” EX1009, [0051], Fig. 3; *see also* EX1009, [0022]

(“device 100 may include a computer processor”), EX1009, [0050]

(“microprocessor 110 can process inputted sensor signals to determine appropriate output actuator signals by following stored instructions”), EX1009, [0062]

(describing “software running upon the microprocessor”); EX1009, [0064] (same), claim 22 (“a memory coupled to [a] processor”).

147. Rosenberg’s processor executes the Haptic Compassing Routines, which I explained above regarding limitation [9A]. EX1009, [0033], [0043] (“device 100 includes a processor 110 for running the Haptic Compassing Routines”), EX1009, [0046] (“under the control of the Haptic Compassing Routines, processor 110 is operative to selectively control one or more actuators 18 by sending a haptic control signal to actuator electronics 116”), EX1009, [0050], [0062].

148. Microprocessor 110 is thus a “*processor configured to execute the haptic representation module,*” i.e., Rosenberg’s Haptic Compassing Routines, “*stored on the memory,*” as claimed.

d. [9C]: “an actuator configured to output one or more haptic effects;”

149. Limitation [1C] recites “*sending the haptic signal to an actuator to generate the haptic effect.*” As I explained previously, when discussing limitation [1C], Rosenberg meets this limitation. Limitation [9C] is the same in relevant

respects, merely substituting “output” for “generate.” Rosenberg meets limitation [9C] for the same reasons it meets limitation [1C].

e. [9D]-[9H]

150. Limitations [9D]-[9H] require the “*haptic representation module*” of limitation [9A] to be configured to perform the steps in limitations [1A]-[1E].

Rosenberg thus discloses limitations [9D]-[9H] for the same reasons it discloses limitations [1A]-[1E], as discussed above.

11. Claim 10

151. Claim 10 requires claim 9’s “*haptic representation module*” to be configured to perform the functionality of claim 2. Rosenberg thus meets claim 10 for the same reasons it meets claims 2 and 9.

12. Claim 11

152. Claim 11 requires claim 9’s “*haptic representation system*” to be used with the vibration actuator of claim 3. Rosenberg thus meets claim 11 for the same reasons it meets claims 3 and 9.

13. Claim 12

153. Claim 12 requires claim 9’s “*haptic representation system*” to be used with the deformation actuator of claim 4. As I explained above, Rosenberg meets all of the limitations of claim 9 and meets or renders obvious the limitations of claim 4. Accordingly, Rosenberg (or an obvious implementation of its teachings)

meets or renders obvious claim 12 for the same reasons it meets or renders obvious claims 4 and 9.

14. Claims 13, 21, and 26

154. Independent claims 13, 21, and 26 largely mirror independent claims 1, 5, and 9. For example, limitations [13B]-[13C] and [13F]-[13G] are identical to limitations [1B]-[1E]. Limitations [21B]-[21C] and [21F]-[21G] are identical to limitations [5B]-[5E]. Limitations [26A]-[26C], [26E]-[26F], and [26I]-[26J] are identical to limitations [9A]-[9C] and [9E]-[9H].

155. The only distinctions between the two sets of independent claims are:

- (a) the “*input*” received from a “*sensor*” in limitations [13A], [21A], and [26D] is not limited to “*extra-sensory information*” (ESI) as in limitations [1A], [5A], and [9D]; and
- (b) the “*haptic signal*” and “*haptic effect*” in limitations [13D]-[13E], [21D]-[21E], and [26G]-[26H] are limited to “*at least one of a force haptic signal[/effect], a deformation haptic signal[/effect], or an impedance haptic signal[/effect],*” whereas claims 1, 5, and 9 recite simply a “*haptic signal*” and “*haptic effect.*”

156. Claims 13, 21, and 26 are thus broader than claims 1, 5, and 9 in sense (a) but narrower in sense (b).

157. Although claims 13, 21, and 26 do not limit the input received from the sensor to ESI, they cover using ESI because they recite “input from a sensor” with no limitation on the type of input. Thus, Rosenberg’s ESI “orientation data” is “*input from a sensor*” as recited in claims 13, 21, and 26.

158. As I explained above regarding claim 4, Rosenberg discloses, and renders obvious, using a deformation actuator to generate a deformation haptic effect. When Rosenberg (or an obvious implementation thereof) uses a deformation actuator, its “haptic control signal” is a “*deformation haptic signal*” producing a “*deformation haptic effect*,” as recited in limitations [13D]-[13E], [21D]-[21E], and [26G]-[26H]. In addition, as I explain below regarding claims 15, 23 and 28, Rosenberg also discloses using an actuator to generate a “*force haptic effect*” as claimed. *See also* EX1009, [0050] (“a single force or a sequence of forces output by the actuator”). For Rosenberg to generate such a force haptic effect, Rosenberg’s processor sends a corresponding command signal to the actuator, which is a “*force haptic signal*” as claimed. *See, e.g.*, EX1009, [0050] (“microprocessor 110 can [] determine appropriate output actuator signals”).

159. Because the remaining limitations of claims 13, 21, and 26 mirror those of claims 1, 5, and 9, Rosenberg meets them for the same reasons it meets corresponding limitations of claims 1, 5, and 9.

15. Claims 14, 22, and 27

160. Claim 14 depends from independent claim 13. Claim 22 depends from independent claim 21. Claim 27 depends from independent claim 26. Each of claims 14, 22, and 27 limits the “*input*” of their respective independent claims to “*extra-sensory information.*” Rosenberg meets claims 14, 22 and 27 for the same reasons it meets limitations [1A], [5A], and [9D].

16. Claims 15, 23, and 28

161. Claim 15 depends from independent claim 13. Claim 23 depends from independent claim 21. Claim 28 depends from independent claim 26. Claims 15, 23, and 28 limit the “*haptic effect*” of their respective independent claims to a “*force haptic effect*” that “*causes a device to apply a force to user.*” As I noted previously, each embodiment of Rosenberg addressed herein provides a “tactile sensation.” EX1009, [0062], [0064], [0068]-[0072]. Rosenberg discloses that its available “tactile sensations” include a “single force or a sequence of forces” such as a “single jolt.” EX1009, [0050]. This disclosure meets the language of claims 15, 23 and 28 because it describes using “force” as a haptic effect, and that means applying a force to a user. Indeed, a “jolt” is similar to the ’546 patent’s “jerk sensation,” which the ’546 patent describes as a “force effect[.]” EX1001, 5:50-52. Rosenberg’s force haptics naturally cause Rosenberg’s device to “*apply force to a user,*” as claimed.

17. Claim 16

162. Claim 16 depends from claim 15, and limits the “*force haptic effect*” of claim 15 to one that “*causes a device to apply a pressure to the user’s body.*” Pressure is simply force per unit area. For example, “pressure” is defined by the New Oxford American Dictionary as “the force exerted per unit area,” EX1019, and by the American Heritage Dictionary of the English Language as “[f]orce applied uniformly over a surface, measured as force per unit area.” EX1020. Rosenberg’s “single jolt” applies a “single force” that is “felt by a user holding the device.” EX1009, [0050], [0036]. Rosenberg also describes: “Some actuators may be mounted upon a user contactable surface of the portable computing device.” EX1009, [0032]. A user contactable surface necessarily has an area. A POSA would therefore understand Rosenberg teaches applying a force over a surface of the user’s hand or finger (namely a part of the user’s body) holding the device, which is by definition an application of pressure to the user’s body. Rosenberg thus meets claim 16.

18. Claims 17, 24, 29

163. Claim 17 depends from independent claim 13. Claim 24 depends from independent claim 21. Claim 29 depends from independent claim 26. Claims 17, 24, and 29 limit the “*deformation haptic effect*” of their respective independent claims to one that “*causes a device to deform.*” As I discussed above in the context

of claim 4, Rosenberg (or an obvious implementation of its teachings) discloses that a “surface of the...device” may comprise an EAP, which deforms. EX1009, [0036]; EX1018, 3 (active polymer “acting as the active functional unit, i.e., the actuator” can “change its volume by swelling or shrinking more than 90%”). Rosenberg thus meets or renders obvious claims 17, 24, and 29 for the same reasons it meets or renders obvious claim 4.

19. Claim 18

164. Claim 18 depends from claim 17, and limits claim 17 by requiring that *“the deformation haptic effect causes the device to modify at least one of a macro-shape of the device or a texture of the device, and wherein the deformation of the devices comprises at least one of a visual deformation, a haptic deformation, a quasi-static deformation, or a dynamic deformation.”* As discussed previously, Rosenberg (or an obvious implementation of its teachings) discloses that the device’s surface may comprise an EAP. EX1009, [0036]. EAPs deform, including by changing their volume, and hence their shape, i.e., a “haptic deformation.” EX1009, [0036]; EX1018, 2 (active polymer “acting as the active functional unit, i.e., the actuator” can “change its volume by swelling or shrinking more than 90%”). Rosenberg also discloses that its “tactile sensation” can be a “texture sensation.” [0050]. Rosenberg thus meets or renders obvious claim 18 for the same reason it meets or renders obvious claim 4.

**B. Ground 2: Brock Anticipates and/or Renders Obvious
Claims 1-3, 5-7, 9-11, 13-16, 21-23, and 26-28**

1. Brock (EX1008)

165. I refer to U.S. Patent Application Publication 2002/0120188 (EX1008) as “Brock” because David L. Brock is the first named inventor. Brock’s cover page reflects that it was published on August 29, 2002. I understand from counsel that Brock qualifies as indisputable prior art to the ‘546 Patent because it was published more than one year before the ’546 patent’s filing date of August 29, 2012.

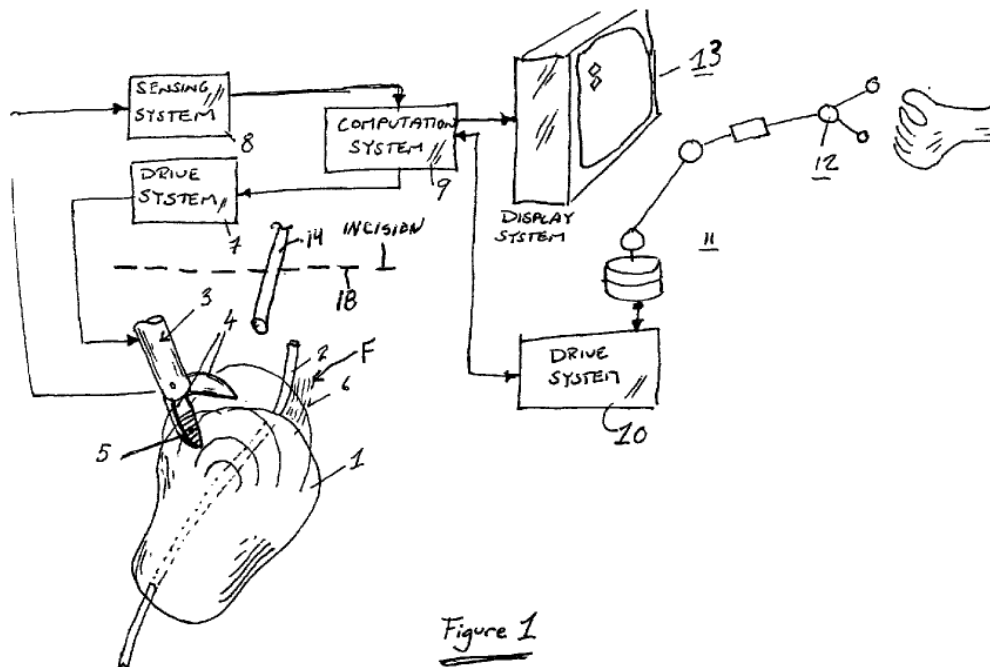
166. Brock discloses a system that enables a surgeon to perceive the location of certain anatomical structures (e.g., nerves or blood vessels) while controlling an instrument inside a patient’s body, to avoid cutting those structures unintentionally. EX1008, [0006], [0020]-[0021], [0026]-[0031]. The idea of Brock is that the surgeon can take advantage of haptic feedback indicating that sensitive structures are in proximity to a surgical device, to avoid inadvertently damaging those structures.

167. Brock’s instrument has, or has a connection to, a “manipulator” (e.g., handle or telerobotic interface) used to control the instrument. A sensor can be located at the instrument’s tip to detect what Brock calls a “non-visible” parameter, e.g., an electric field surrounding a nerve. EX1008, [0029], [0059]-[0067], [0073]-[0075], [0078]-[0082], Figs. 1-6, claims 29-40. The system includes a controller

which generates a haptic effect in the manipulator based on the sensed non-visible parameter. For instance, the system can produce tactile (haptic) feedback like force or vibration in the manipulator when the field is sensed, alerting the surgeon that the instrument is approaching something the surgeon should avoid cutting. EX1008, Abstract, [0026]-[0031], [0035]-[0039], [0042]-[0043], [0048]-[0049], [0054]-[0056], [0059]-[0067], [0069], [0089]-[0101], [0132]-[0136]. Brock uses the terms “haptic” and “tactile” synonymously. For example, Brock talks about providing “a tactile signal at a haptic user interface.” EX1008, [0021], [0023]; *see also* EX1008, [0028], [0067], [0100], [0108] (“Preferably, the feedback signal is a signal that the surgeon ‘feels’ (tactile) at the haptic interface...”).

168. The system modulates the haptic effect based on changes in the sensed non-visible parameter, [0056], [0084], [0089], [0094], [0134], for example controlling a “vibration level.” EX1008, [0056]. “The magnitude of the vibration may be a function of the proximity of the end effector to the field.” EX1008, [0094].

169. I have reproduced Figure 1 of Brock below, which is a schematic of an embodiment of Brock’s invention in the context of a telerobotic surgical instrument. EX1008, Fig. 1, [0059], [0026], [0085].



170. Brock depicts in Figure 1 a surgical instrument 3, including a tool 4, inside a patient, proximate tissue 1. EX1008, [0077]-[0078]. Figure 1 also shows a sensor 5 at the tip of instrument 3. EX1008, [0080]. The output from sensor 5 couples to sensing system 8, which in turn couples to computation system 9. EX1008, [0080]. Drive system 7 is coupled between computation system 9 and instrument 3 for controlling the instrument. EX1008, [0080]. Another drive system 10 is coupled between computation system 9 and haptic interface 11, which includes handle 12. EX1008, [0081]. Using haptic interface 11, the surgeon can control instrument 3 via the drive systems. EX1008, [0082].

171. Brock further discloses that the system may “provide feedback to the haptic interface 11.” EX1008, [0089]. Sensor 5 can sense a “non-visible field” associated with an anatomical structure, such as an electric field or a thermal,

radioactive, infra-red, or other non-visible field. EX1008, [0025] (“The sensed parameters include non-visible data (electromagnetic, thermal, infra-red, radioactive, etc.”), [0053] (“The non-visible field may be an electric field (which as used herein includes an electromagnetic field), a thermal field, a radioactive field, an IR field, or any other type of non-visible field.”), [0074] (“Following injection of a radiolabeled substance, dissection and sensing of the radioactivity proceed simultaneously. The degree of radioactivity may be mapped to a vibrational signal, tactily indicating to a surgeon proximity to a critical tissue site, (e.g., lymph node, abscess pocket or other radio-tagged tissue.”), [0079] (“electric field F...is considered as a non-visible field...the sensing in accordance with the present invention can [also] be thermal, radioactive, IR and other types of fields associated with anatomic structures, and including self-excited fields”), [0011]-[0014] (explaining that nerves produce electric fields, blood vessels produce thermal variations, lymph nodes can be radioactively tagged). The tactile feedback provided through the haptic interface can be based on the detected field’s strength, to signal the surgeon that the instrument is getting closer to an anatomical structure that should be avoided. EX1008, [0056], [0094], [0089].

172. Figure 1, for instance, shows nerve 2 near the surgical instrument. EX1008, [0079]. An electric field F (shown in Figure 1) is associated with the nerve. EX1008, [0039], [0068]-[0070], [0079]. Brock also explains that “as the

sensor 5 gets closer to the nerve 2, the field strength increases.” EX1008, [0089]. “This measured strength, sensed by the sensor, is coupled by way of the sensing system 8 to the computation system 9, and from there to drive system 10 and haptic interface 11.” EX1008, [0089]. The feedback from the sensor can be used to generate a haptic effect in handle 12 such as vibration or force feedback “in order to inhibit [] further action at the end effector” and to “signal to the surgeon that he is in the vicinity of the nerve and must be careful to not cause a dissection of the nerve.” EX1008, [0090]. “This control is on a real-time basis.” EX1008, [0089].

173. I have reproduced Brock’s Figure 3 below, which depicts essentially the same haptic-feedback system deployed in the context of a manual (non-robotic) surgical instrument. The surgeon manipulates hand-held instrument 30 using operating handle 32, implemented as a haptic interface. EX1008, [0092]. Sensor 5 is included at end effector 34 of instrument 30. EX1008, [0092].

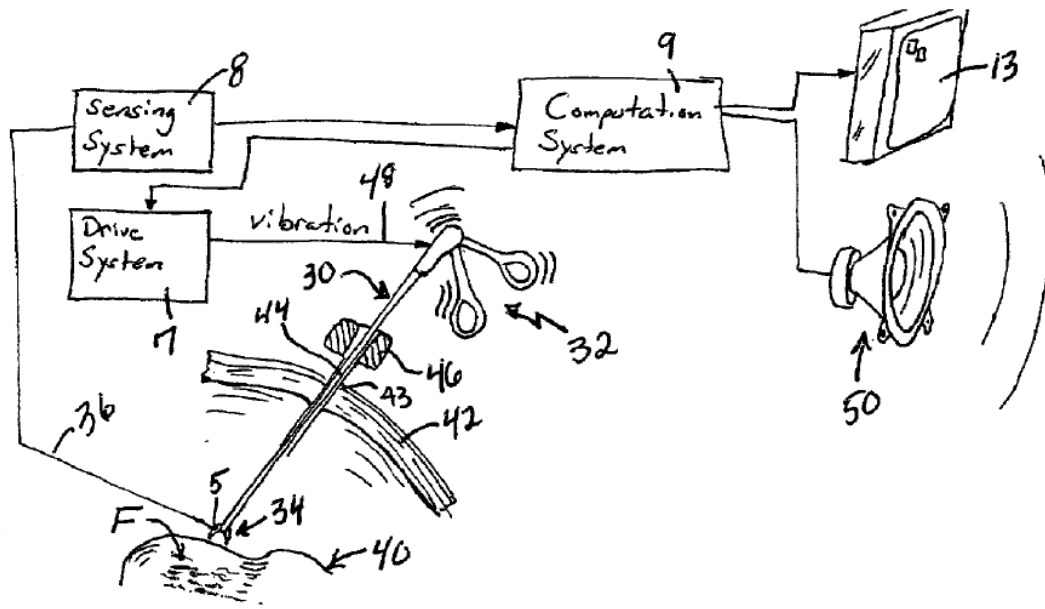


FIG. 3

174. As shown in Figure 3, drive system 7 generates, and provides to operating handle 32, “a vibration signal as an indication to the surgeon at the handle 32 that the end effector 34 is coming into close proximity to a sensed non-visible field F.” EX1008, [0094]. This causes vibration at handle 32. EX1008, [0094]. “The magnitude of the vibration may be a function of the proximity of the end effector to the field.” EX1008, [0094]. The vibration “provide[s] the surgeon with tactile...feedback based upon sensed non-visible parameter.” EX1008, [0096].

175. Brock’s invention includes a “controller, intercoupling the sensing device and the manipulator,” with “a mapping component for translating the characteristics of the sensed field signal into a tactile feedback signal to the manipulator to warn the surgeon that he is approaching” a sensitive structure.

EX1008, Abstract. *See also* EX1008, [0028], [0036] (“Also included is a controller coupled from the sensor, responsive to the magnitude of the field, for feeding back to the master station a control signal to the surgeon interface so as to provide a tactile response to the surgeon based upon the magnitude of the detected field.”), [0038] (“The medical device includes...a controller coupled from and responsive to the sensor for providing at the handle a tactile indication to the surgeon based on a predetermined parameter of the field.”), [0048], [0067] (“With a controller, the digital signal can be mapped to, for example, a tactile feedback (palpable hardness or vibration sense) provided at a surgeon’s tactile (haptic) interface.”), [0101] (“The controller(s) also control feedback to the haptic interface 140, such as from the sensors.”), [0108] (“[T]he controller provides a force feedback signal to the manipulator, or haptic interface 140 illustrated in FIG. 5....Preferably, the feedback signal is a signal that the surgeon ‘feels’ (tactile) at the haptic interface....”), [0133]-[0136].

176. I have reproduced Brock’s Figure 5 below, which depicts a controller 136 that receives input from various sensors. It controls, *inter alia*, haptic interface 140, for example providing a signal causing a “tactile” haptic response. EX1008, [0099], [0101], [0108], [0132]-[0134]. The tactile feedback is “carried out preferably in ‘real time’.” EX1008, [0134]. *See also* EX1008, [0026]-[0027], [0075], [0089], [0099], claims 33, 39.

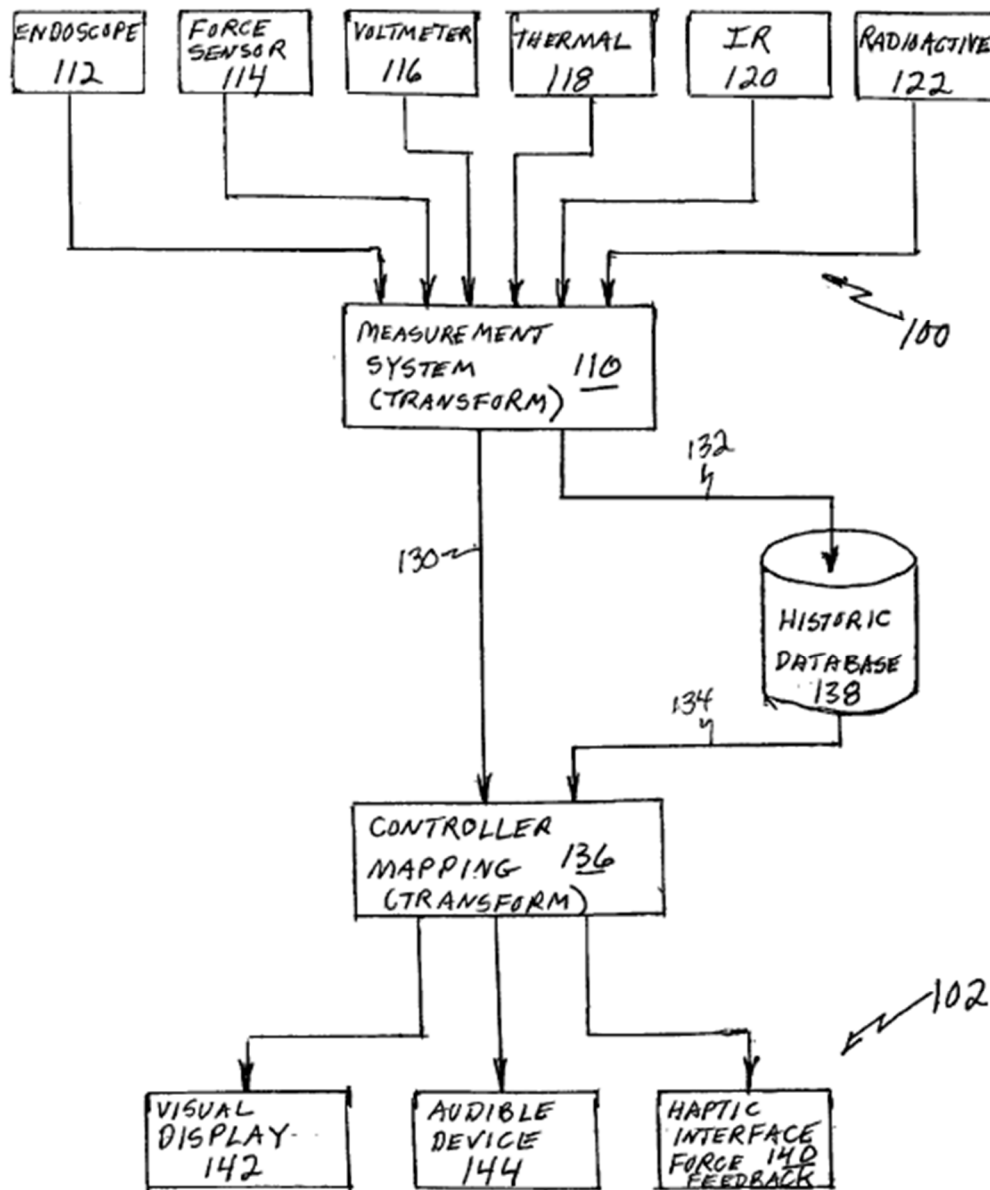


FIG. 5

177. Although Figure 1 is described as “illustrating an embodiment” ([0059]) and Figure 3 is described as depicting “an alternative embodiment” ([0092]), I note that the primary difference between Figures 1 and 3 is the type of instrument. In Figure 1, a robotic instrument is controlled remotely. EX1008,

[0080]-[0082]. In Figure 3, the instrument is “hand-held” ([0061]); the surgeon controls it directly. EX1008, [0094]. The thrust of Brock is providing haptic feedback to a surgeon in both situations. EX1008, [0026], claims 29, 32, 35, 38. Brock explains that its controller maps sensed field strength to haptic feedback at the haptic interface. Although not shown in Figures 1 or 3, the controller is a common element of Brock’s embodiments, EX1008, [0063] (Figure 5 shows “relationships between sensed parameters, transformed data and signals, and applied outputs, *according to various embodiments*”) (emphasis added)—and is the component that maps sensor input to haptic output. Accordingly, I consider Brock’s Figures 1, 3 and 5, and their related textual descriptions together when evaluating whether certain of the challenged claims are patentable in view of Brock, as discussed below.

178. As I will explain below, in my opinion Brock renders obvious claims 1-3, 5-7, 9-11, 13-16, 21-23, and 26-28.

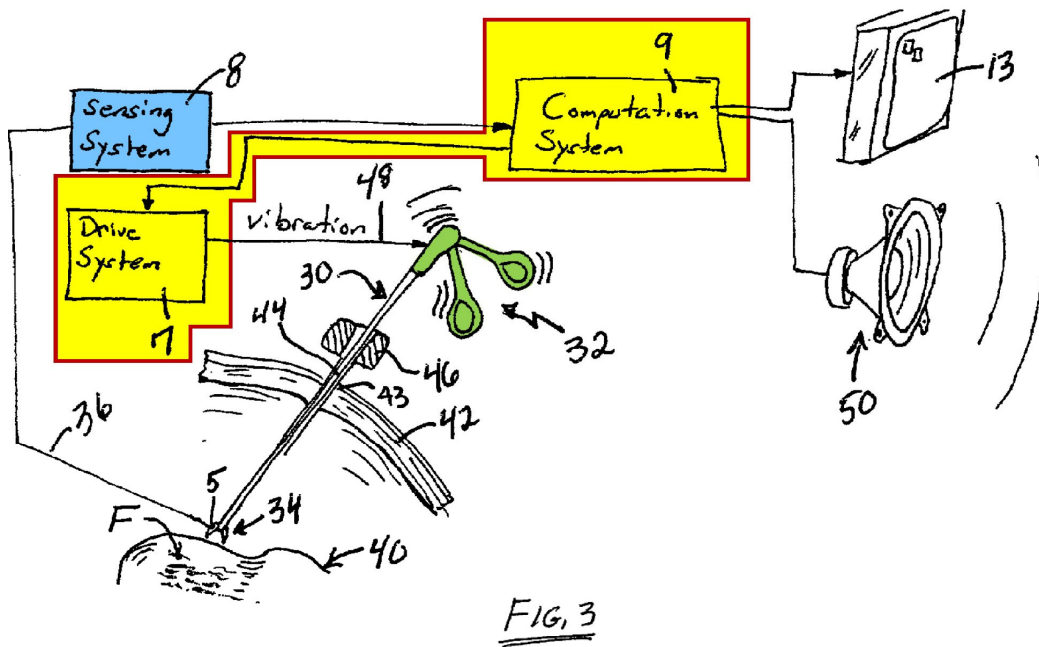
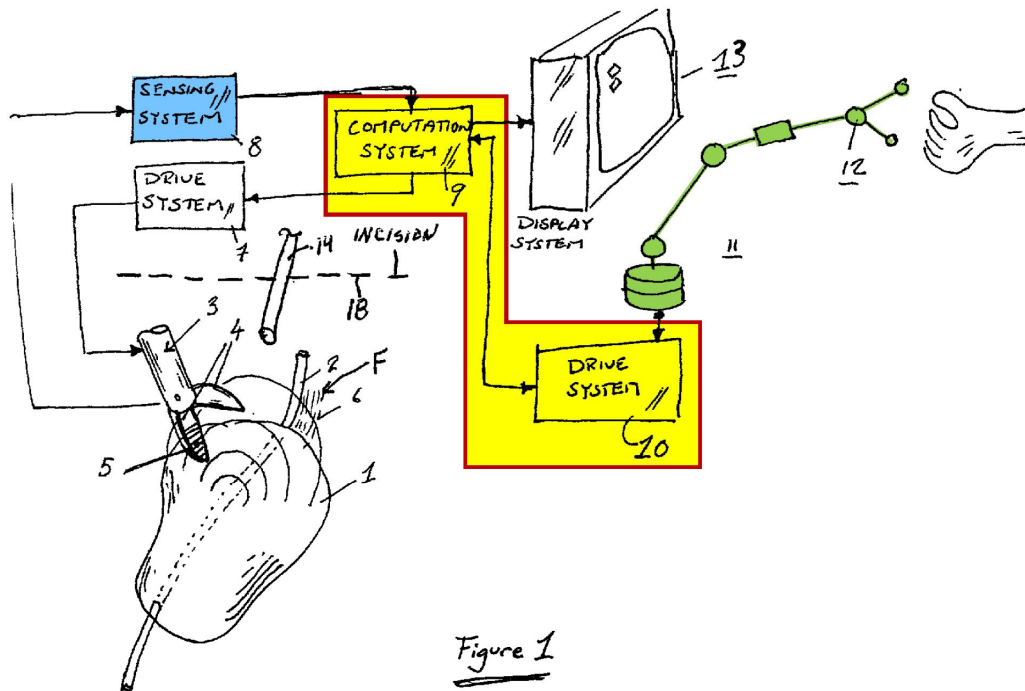
2. Claim 1

- a. [1PRE]: “A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:”**

179. Brock meets [1PRE]. Brock’s haptic feedback system includes a “computation system” and a “drive system” coupled to a handle. EX1008, Figs. 1,

3, [0077]-[0094]. For example, Figure 1 shows a computation system 9 and a drive system 7. In connection with Figure 3, Brock explains, “the computation system 9 along with the drive system 7 causes a signal on line 48 to cause a vibration at the handle 32” ([0094]), making handle 32 a “haptic interface” ([0092]). In my opinion this vibration at the handle is a “*haptic effect*” as claimed. Similarly, in connection with Figure 1, the specification explains that computation system 9 and drive system 10 are connected to “haptic interface 11” including “handle 12” (EX1008, [0081]), and provide “feedback...at the handle 12” including “vibration” (EX1008, [0089]-[0090]). In particular, I note that Brock explains that its “controller” maps a sensed field signal to a “tactile feedback signal to the manipulator.” EX1008, Abstract. Tactile feedback at a haptic interface is a haptic effect. It is therefore my opinion that Brock discloses generating a “*haptic effect*” as claimed. *See also* EX1008, [0020]-[0023], [0025]-[0030], [0035], [0043], [0067], [0073]-[0075].

180. I have reproduced Figures 1 and 3 below and used color-coding to show how Brock’s computation system and haptic drive system (yellow) are situated between the sensing system 8 (blue) and the device exhibiting the haptic effect (green).



181. As I noted above, Brock's controller 136 (shown in Fig. 5) provides "signal mapping" and "control[s] feedback to the haptic interface." EX1008, [0101]; *see also* EX1008, Fig. 5, Abstract, [0028], [0035]-[0038], [0052]-[0055],

[0067], [0099]-[0102], [0108], [0133]. In my opinion a POSA would have understood that Brock's controller is located in the computation system or drive system, since Brock states that "the computation system 9 along with the drive system 7 causes a signal on line 48 to create a vibration at the handle 32" ([0094]), and generating a haptic signal is ultimately the job of the controller as explained repeatedly in Brock. EX1008, [0036] ("a controller coupled from the sensor, responsive to the magnitude of the field, for feeding back to the master station a control signal to the surgeon interface so as to provide a tactile response to the surgeon based upon the magnitude of the detected field"), [0133] ("A controller intercouple the surgical implement, manipulator and sensing device and includes a mapping block for translating predetermined characteristics of the non-visible field from the sensing device into a signal for controlling actions at the manipulator. The signal for controlling actions usually controls a tactile feedback to the operator."), [0136] ("A controller...includes a mapping block for translating predetermined characteristics of the non-visible field from the sensing device into a vibration signal coupled to the manipulator."). *See also* EX1008, [0084], [0086], [0119], [0139] (describing "computer control").

182. Based on the controller's mapping functionality, which involves computation, in my opinion a POSA would have understood that Brock's controller comprises a processor. Further, because the processor must execute

instructions (that is what processors do, and in this case instructions are needed to map sensor inputs to haptic outputs such as vibration) a POSA would also understand that memory would be needed to store those instructions. It would be standard practice for that memory to be a non-transitory computer-readable medium, as that term includes RAM, ROM, and permanent storage such as a hard drive for reasons I discussed previously.

183. Further, use of the term “controller” in the prior art reinforces my conclusion that a POSA would understand Brock’s “controller” comprises a processor that executes instructions stored in a non-transitory computer-readable medium. For example, Pratt (EX1021, which I understand from counsel is prior art to the ’546 patent) discloses a device, employing haptic effects like vibration, that includes a “UI controller” that receives sensor inputs and generates corresponding haptic commands. EX1021, [0025]; *see also* EX1021, Abstract, [0014]. Pratt’s “controller” comprises processor 112 and memory 114. EX1021, Fig. 1(a), [0015], [0017]. Pratt’s memory 114 “may be provided as a non-volatile memory, a volatile memory such as random access memory (RAM), or a combination thereof,” and stores instructions, executed by the processor, to “control the operations of the UI controller.” EX1021, [0017]. In my opinion Pratt thus corroborates that a POSA understood that the term “controller”—including a “controller” used to generate haptic effects—typically described a component

comprising a processor that executes instructions stored on a non-transitory computer-readable medium.

184. I understand that a POSA is considered a “hypothetical” person who is aware of, and capable of understanding, the prior art. Thus, a POSA’s knowledge would include Pratt and the other corroboratory prior art references discussed herein and below.

185. I have also considered U.S. Publication 2012/0143182 (“Ullrich ’182,” EX1022), which I understand from counsel is also prior art to the ‘546 patent. Ullrich ’182 provides similar corroborating evidence. It discloses a surgical tool that generates haptic effects. The device has a “control system 112” that receives input from sensors 140 and sends output to haptic feedback system 120. EX1022, Fig. 2, [0028]. “Control system 112” comprises a processor 116 and tactile mapping logic 118, which in turn “may be associated with a memory device...for storing...instructions.” EX1022, Fig. 2, [0026]. The memory device may be RAM or ROM (both of which are non-transitory computer-readable media as I explained previously), and may store “logical instructions, commands and/or code executed by tactile mapping logic 118,” which “outputs control signals to haptic feedback system 120.” EX1022, [0026]-[0027]. Ullrich ’182 thus provides further corroboration that a POSA understood a control system such as Brock’s

“controller” to comprise a processor that executes instructions stored on a non-transitory computer-readable medium.

186. If the Board were to conclude that Brock’s controller does not disclose a “processor” and/or a non-transitory computer-readable medium storing instructions for execution by the processor it is my opinion that a POSA would have recognized that Brock’s controller renders those features obvious for the reasons I will discuss immediately below. Indeed, it would not even be possible to have a “controller” without a processor to execute instructions, and memory to store those instructions.

187. More specifically, with respect to the non-transitory computer-readable medium: RAM and/or ROM—the same memories described in the ’546 patent (EX1001, 2:55-59)—were ubiquitous in the prior art for storing instructions in similar contexts. Rosenberg is one example, as discussed above when I evaluated claim 1 in view of Rosenberg. Other corroboratory examples include Ramstein (EX1014, which I understand from counsel is also prior art), directed to a surgical tool with a sensor and a system that provides haptic feedback in response to a sensor signal. EX1014, Abstract. Just like the ’546 patent, Ramstein discloses RAM or ROM to store instructions for execution by a processor, which instructions control an actuator to provide a haptic effect. EX1014, [0019]-[0021]. *See also* EX1021, [0017]; EX1022, [0026]-[0027]. In short, based on a POSA’s

knowledge, it is my opinion that it would have been obvious to store instructions for generating Brock's haptic effect on a non-transitory computer-readable medium.

188. With respect to the processor, in my opinion it would also have been obvious to a POSA to use a processor to execute instructions to generate a haptic effect such as that described in Brock, as was ubiquitous in the prior art.

Rosenberg is one example, as discussed above when I evaluated claim 1 in view of Rosenberg. Other corroboratory examples include Ramstein (EX1014), which discloses a processor 22 for processing instructions to control an actuator to provide a haptic effect. EX1014, [0019]-[0021]. *See also* EX1021, Fig. 1(a), [0015], [0017]; EX1022, Fig. 2, [0026]-[0027].

189. Accordingly, in my opinion claim 1's preamble is satisfied by Brock's controller, which a POSA would have understood to comprise a processor and a non-transitory, computer-readable medium containing instructions that, when executed by the processor, generate a haptic effect. Further, because the use of such a processor and memory in Brock's system would have been obvious, the preamble is obvious over Brock in view of a POSA's knowledge.

- b. [1A]: “receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;”

190. Brock meets [1A]. In connection with Figures 1 and 3, Brock discloses a sensor 5 at or near the medical instrument’s tip. EX1008, [0080], [0092], Figs. 1, 3. It senses a “non-visible field” described generally as “field F.” EX1008, [0079], [0094].

191. According to Brock, a non-visible field is “not observable...by the naked eye.” EX1008, [0029]. This matches the ’546 patent’s “*extra-sensory information*,” described in the ’546 patent as “information that cannot normally be perceived by a human being.” EX1001, 2:17-19. As examples of non-visible fields sensed by its sensor, Brock lists electromagnetic (e.g., electric, which is a type of electromagnetic field), thermal, infrared, and radioactive fields. EX1008, [0025], [0029], [0053], [0065], [0079]. In my opinion, these fields all qualify as “*extra-sensory information*,” as claimed, because they cannot normally be perceived by a human being. In particular, electric fields, on which Brock focuses, cannot normally be perceived by a human bring. Further, the fields listed in Brock closely match the examples of “*extra-sensory information*” in the ’546 patent: “electromagnetic field, infra-red light, ultraviolet light, radiation, or subtle changes in temperature.” EX1001, 2:17-20.

192. Brock's sensor 5 is connected, via sensing system 8, to computation system 9 and a drive system. EX1008, [0080], [0092]-[0094], Figs. 1, 3. The non-visible field information sensed by sensor 5 is provided as input to computation system 9 and the drive system. EX1008, [0089] ("This measured strength, sensed by the sensor, is coupled by way of the sensing system 8 to the computation system 9, and from there to drive system 10 and haptic interface 11."). *See also* EX1008, [0020], [0022], [0086]. In particular, the sensor input is provided to Brock's "controller," which a POSA would have understood is in the computation system or drive system (as I explained above). EX1008, Abstract, [0028], [0036], [0038], [0048]. Thus, it is my opinion Brock meets "*receiving input from a sensor, wherein the input comprises extra-sensory information*" as claimed.

193. The "non-visible data" that Brock's computation system and drive system receive as input from sensor 5 comprise "*one or more interaction parameters,*" as claimed. Indeed, Brock says the input comprises a "parameter." EX1008, [0025], [0028], [0096]. That parameter is an "*interaction parameter,*" as claimed, because it is based on the user's interaction with the surgical device (e.g., interaction with the "manipulator" to control and move the instrument, [0133]-[0134]). For example, "as the sensor 5 gets closer to the nerve 2, the field strength increases. This measured field strength, sensed by the sensor, is coupled by way of the sensing system 8 to the computation system 9, and from there to drive system

10 and haptic interface 11.” EX1008, [0089]. Brock is directed to interactive surgery during which a human surgeon is using a device to perform cutting, palpation (feeling with fingers), dissection, etc. EX1008, [0007]- [0008]. For example, Brock describes a surgeon-manipulated “non-robotic system (e.g., in association with a hand-held instrument, such as a laparoscopic instrument)”. EX1008, [0026]. Because the “measured strength” varies based on how close the surgeon moves the sensor to the nerve, it is based on the surgeon’s interaction with the device and thus meets the claimed “*interaction parameter*.” See also EX1008, [0025] (non-visible data are “parameters”), EX1008, [0028] (“a feedback signal which is a function of a sensed parameter of the non-visible field...fed back to the haptic interface...), EX1008, [0094], EX1008, [0096] (“The control may also include feedback to the haptic interface...based upon sensed non-visible parameter:”), EX1008, [0134] (“A feedback occurs...indicating that the instrument is now at a location that corresponds with a certain field intensity.”).

194. In my opinion the “measured strength” of the field also “*comprises a value*” because a “strength” has a value (e.g., a magnitude). Brock teaches that “the sensed or predetermined parameter may comprise a magnitude of the field” (EX1008, [0031]) and that such sensed “values” of “non-visible parameters” can be stored (EX1008, [0075]). For example, the sensor measuring field strength can be “a voltmeter” (EX1008, [0080]), which a POSA would understand would be

used to measure electric field strength in values of, e.g., volts. *See also* EX1008, [0029] (“A ‘field’ may also be identified as...sensory information which constructs a data set of **values**”) (emphasis added), [0036] (Brock provides “a tactile response to the surgeon based upon the magnitude of the detected field”), [0084] (“As the instrument/sensor is moved, different voltages are sensed...”), [0086] (“one can establish intensity levels for all sensed locations”), [0092], [0098].

195. Thus, in my opinion Brock satisfies limitation [1A].

c. [1B]: “mapping the received input to a haptic signal; and”

196. Brock meets [1B]. As I explained above regarding limitation [1A], Brock’s controller, which receives input from the sensor, “includes a mapping component for translating characteristics of the sensed field signal into a tactile feedback signal to the manipulator to warn the surgeon that he is approaching this structure with the implement.” EX1008, Abstract. *See also* EX1008, [0028], [0035], [0036] (“a controller coupled from the sensor, responsive to the magnitude of the field, for feeding back to the master station a control signal to the surgeon interface so as to provide a tactile response to the surgeon based upon the magnitude of the detected field”), [0038], [0089], [0094], [0100]-[0101], [0132] (“Mapping Non-Visible Field to Haptic Interface”), [0133] (“A controller intercouple the surgical implement, manipulator and sensing device and includes a mapping block for translating predetermined characteristics of the non-visible field

from the sensing device into a signal for controlling actions at the manipulator. The signal for controlling actions usually controls a tactile feedback to the operator.”), [0135] (“Mapping Non-Visible Field to Vibration”), [0136] (“A controller...includes a mapping block for translating predetermined characteristics of the non-visible field from the sensing device into a vibration signal coupled to the manipulator.”). In short, the “signal” transmitted by the controller to the manipulator is a “*haptic signal*” to which the received sensor input is “*mapp[ed]*,” as claimed.

d. [1C]: “sending the haptic signal to an actuator to generate the haptic effect;”

197. Brock meets [1C]. Brock explains that its controller sends a tactile feedback signal, such as a vibration signal, to the manipulator. EX1008, Abstract (controller sends a “tactile feedback signal to the manipulator to warn the surgeon that he is approaching this structure with the implement”), EX1008, [0094], [0133] (“A controller intercouple the surgical implement, manipulator and sensing device and includes a mapping block for translating predetermined characteristics of the non-visible field from the sensing device into a signal for controlling actions at the manipulator. The signal for controlling actions usually controls a tactile feedback to the operator.”), EX1008, [0136] (“A controller is provided intercoupling the surgical implement, manipulator and sensing device and includes a mapping block for translating predetermined characteristics of the non-visible field from the

sensing device into a vibration signal coupled to the manipulator.”). The “manipulator,” which receives the aforementioned signal, may be either haptic interface 11 in Figure 1 or handle 32 in Figure 3. EX1008, [0112], [0114]. Vibration and tactile effects are haptic effects. EX1008, [0094], [0136]; *see also* EX1001, Abstract (“Haptics is a tactile...technology” and vibrations are “haptic effects”), 4:42-43 (vibration is a “haptic effect[.]”). Therefore, in my opinion when Brock’s controller sends a “tactile feedback signal to the manipulator,” it is “*sending the haptic signal*,” as claimed.

198. While Brock does not use the word “actuator,” a POSA would have understood that an actuator is simply a device that actuates (i.e., moves) something. For example, the American Heritage Dictionary of the English Language defines “actuator” as “a device responsible for actuating a mechanical device,” and “actuate” as “[t]o put into motion.” EX1024. The New Oxford American Dictionary defines “actuate” as “cause (a machine or device) to operate.” EX1023. As another example, the ’546 patent describes a device that causes vibration as a “vibration actuator” and a device that generates force is a “force actuator.” EX1001, 2:29-34. In my opinion a POSA would have understood that Brock’s “manipulator”—which receives the claimed “*haptic signal*” from Brock’s controller as discussed above, and comprises an instrument or haptic interface that

exhibits a haptic effect, EX1008, [0025], [0043], [0048], [0054], [0133] [0136]—comprises an “*actuator*,” as claimed.

199. Further, in my opinion the use of an actuator would have been obvious, as actuators were ubiquitous in the prior art for creating haptic effects. Rosenberg is one example, as I discussed when evaluating claim 1 in view of Rosenberg. Indeed, Brock describes a “vibratory device,” and says handle 32 is a “haptic interface,” EX1008, [0025], [0092], and a POSA would understand that a typical implementation of a “haptic” device with a vibrating part includes an actuator. *E.g.*, EX1014, [0019] (“Actuator 28 is a haptic device that generates a vibration on handle 16.”); EX1021, [0027] (“haptics actuator” produces “haptic effect”), EX1022, [0028] (“haptic actuator” produces “haptic feedback to the operator”); EX1025, [0016] (“Actuator 18 is a haptic device that generates a vibration on telephone 10.”). Based on a POSA’s knowledge, in my opinion it would have been obvious to implement Brock’s sending a “tactile feedback signal to the manipulator” (EX1008, Abstract) by sending the signal to an actuator in the manipulator.

- e. **[1D]: “the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and”**

200. Brock meets [1D]. As I explained above regarding limitation [1B], Brock’s mapping functionality, which resides in Brock’s controller, maps non-visible field input from the sensor to a signal that causes a haptic effect.

201. Brock’s mapping functionality “*further compris[es] modulating the haptic signal when new input is received,*” as claimed. Per Brock, the “magnitude of the vibration may be a function of the proximity of the end effector to the field.” EX1008, [0094]. *See also* EX1008, [0069] (“differing electrical forces and dipoles can be mapped and then provided to the surgeon as different degrees of hardness/softness, or vibration”). Thus, based on a “measured strength, sensed by the sensor,” Brock’s system provides “feedback” that “can be used to indicate at the handle 12 that the distal end is approaching an area where there is a nerve.” EX1008, [0089]. “This control is on a real-time basis.” EX1008, [0089]. *See also* EX1008, [0075], [0099] (line 130 in Fig. 5 depicts “real time” sensed data to control a haptic interface), [0134] (the “tactile feedback is carried out preferably in ‘real time.’”), claims 29, 39. In my opinion, the phrase “real time” means that Brock provides feedback that changes according to the changed sensor input. Thus, the measured field strengths, received from the sensor in “real time,” are

“*new input[s]*,” as claimed, based upon which haptic effects are modulated as I described earlier in this paragraph.

202. Also, a POSA would have understood that since the magnitude of the haptic effect (e.g., vibration) is modulated based on the sensed field strength, Brock’s control signal is also modulated, since the control signal is what controls the magnitude of the haptic effect. *E.g.*, EX1008, [0056] (“The signal for controlling actions may control a vibration level at the manipulator.”). Accordingly, Brock discloses “*modulating the haptic signal when new input is received,*” as claimed.

203. As I explained above regarding limitation [1A], the received input data comprise “*interaction parameters*” that comprise “*at least one value.*” The “*new received input*” (e.g., measured field strength provided by the sensor, as the device moves, on a real-time basis) “*comprises an update of at least one value of at least one interaction parameter of the received input,*” as claimed, because each field-strength measurement provided by the sensor updates the prior measurement. EX1008, [0084] (“As the instrument/sensor is moved, different voltages are sensed relative to the field F as the end effector is moved from position to position.”). *See also* EX1008, [0029], [0031], [0036], [0075].

204. Brock meets limitation [1D] under both potential constructions that I have been asked to consider (as I discussed above in §V.A.2.e). Brock provides

“real-time” control. Indeed, Brock’s control happens via mathematical transformation as in the ’546 patent. For example, Brock’s haptic feedback “may be a function of the proximity of the end effector to the field.” EX1008, [0094]. *See also* EX1008, [0028] (“The controller also is responsive to a feedback signal which is a function of a sensed parameter of the non-visible field. This signal is fed back to the haptic interface to provide a tactile indication to the operator as to the location of the anatomic structure that generated the field.”). Brock’s “function” represents a mathematical transformation of the sensed parameter into a mapped feedback signal. Thus, Brock discloses modulating a haptic signal every time a new sensor input is received, such as when a surgeon moves the device within the patient’s body such that the strength of an electric field generated by a nerve changes. This satisfies the first potential construction since successive sensor inputs are mapped, one after the other, to haptic signals, and the second construction which does not require “continuous” modulation.

- f. **[1E]: “the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.”**

205. Brock meets [1E]. As I explained above regarding limitation [1C], Brock discloses, and renders obvious, “*sending the haptic signal to the actuator to generate the haptic effect.*”

206. I have also discussed how Brock discloses “*modulating the haptic signal*” when addressing limitation [1D].

207. Because Brock’s haptic signal is modulated (*see* limitation [1D]), and Brock’s haptic signal is sent (or was obvious to send) to the actuator (*see* limitation [1C]), it follows that Brock’s modulated haptic signal is sent to the actuator to “*modulate the generated haptic effect,*” as claimed. *See also* EX1008, [0094] (the “magnitude of the vibration may be a function of the proximity of the end effector to the field.”

208. For the above reasons, it is my opinion that Brock meets claim 1, and in view of a POSA’s knowledge, also renders claim 1 obvious.

3. Claim 2: “The non-transitory computer-readable medium of claim 1, the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value;”

209. Brock meets claim 2. As I noted above, Brock discloses providing haptic feedback, e.g., vibration, when an instrument tip approaches a nerve. EX1008, [0090]. Brock further discloses that this “control may be exercised using threshold levels.” EX1008, [0090]. A POSA would have understood Brock’s use of “threshold levels” to mean the haptic effect (and hence the haptic signal causing it) are generated when a parameter (e.g., a field strength) exceeds a specified value — the threshold value.

210. Elsewhere, Brock says an “audible signal may be generated only when the force signal exceeds a preselected threshold.” EX1008, [0051]. As Figure 5 shows, audible device 144 and haptic interface 140 are alternative recipients of a control signal from controller 136. EX1008, Fig. 5. A POSA would have understood that when paragraph [0090] refers to exercising control through haptic feedback “using threshold levels,” it likewise means that haptic feedback will only be provided when a parameter (e.g., a field strength) exceeds a specified value — the threshold value.

211. Furthermore, in the same paragraph Brock discloses that “if the instrument tip gets close to a nerve[], there will be a feedback.” EX1008, [0090]. A POSA would understand that determining whether the instrument tip is “close to a nerve” would require defining a minimum distance below which there is an unacceptable risk of “a scalpel or scissors” “caus[ing] a dissection of the nerve,” (*id.*), and then detecting when the measured distance falls below that minimum. In other words, a POSA would understand Brock to be describing the use of a threshold distance for providing feedback “in order to inhibit or lessen further action.” *Id.* Because the measured field strength is a direct function of the distance between the instrument tip and the nerve, Brock uses the measured field strength as a direct indication of the distance. EX1008, [0089] (“as the sensor [] gets closer to the nerve[], the field strength increases.... This feedback can be used

to indicate...instrument 3 is approaching an area where there is a nerve.”).

Therefore, a POSA would understand that “close to a nerve,” and “[t]his control may be exercised using threshold levels,” EX1008, [0090], conveys that the feedback is triggered by the measured field strength (i.e. interaction parameter as I discussed above) falling below a specific field strength threshold, indicating that the instrument is dangerously closer to the nerve than the corresponding threshold distance. While a specific field strength threshold is not defined in Brock, a POSA would understand the minimum distance would be specified by a surgeon, based on the margin of safety needed to avoid damaging a nerve or other sensitive structure, and the corresponding field strength threshold would be determined using the well-known relationship between distance and field strength (EX1008, [0089]).

212. For at least these reasons, Brock thus meets claim 2.

213. Further, I note that it was well-known in the prior art to implement haptic feedback based on threshold sensed levels. *E.g.*, EX1022, [0042] (“Haptic feedback will be provided to users as force measurements pass through several thresholds.”); EX1021, [0039] (haptic feedback based on a finger’s threshold distance or time). In my opinion Brock, in view of a POSA’s knowledge, renders claim 2 obvious.

4. Claim 3: “The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.”

214. Brock focuses heavily on generating a vibration haptic effect. *E.g.*, EX1008, [0048] (Brocks’s system provides “a signal for controlling vibration at the manipulator”), EX1008, [0054] (similar), EX1008, [0056], [0067], [0069], [0073]-[0075], [0090] (“Thus, as the surgeon manipulates the handle 12, if the instrument tip gets close to a nerve 2, there will be a feedback...to provide...a vibration to the handle 12.”), EX1008, [0094] (a purpose of the system is “to create a vibration at the handle 32”), EX1008, [0100], [0135]-[0136], Fig. 3 (showing vibration of handle 32).

215. Thus, in my opinion Brock meets and renders obvious claim 3 for the same reasons it meets or renders obvious limitation [1C], concerning “*sending the haptic signal to an actuator.*”

5. Claim 5

216. Claim 5 recites a “*computer-implemented method for generating a haptic effect*” that comprises acts that claim 1’s “*instructions*” cause a processor to perform. Brock thus meets or renders obvious claim 5 for the same reasons it meets or renders obvious claim 1.

6. Claim 6

217. Claim 6 depends from claim 5, and recites a “*computer-implemented method for generating a haptic effect*” that comprises acts that the “*instructions*” recited in claim 2 cause a processor to perform. As I explained above Brock meets or renders obvious all of the limitations of claims 2 and 5. Brock thus renders claim 6 obvious for the same reasons it renders claims 2 and 5 obvious.

7. Claim 7

218. Claim 7 depends from claim 5, and limits claim 5’s method to one used with the vibration actuator of claim 3.

219. As I explained above Brock meets or renders obvious all of the limitations of claims 3 and 5. Brock thus renders claim 7 obvious for the same reasons it renders claims 3 and 5 obvious.

8. Claim 9

a. [9PRE]: “A haptic representation system comprising:”

220. Brock discloses a “*haptic representation system*,” as claimed.

221. As I discussed previously, Brock discloses a controller which generates a haptic effect in a manipulator based on a sensed non-visible parameter. The manipulator (e.g., haptic interface 11 in Figure 1 or handle 32 in Figure 3) includes, and also renders obvious the use of, an actuator for creating a haptic effect.

222. The '546 patent explains that a “*haptic representation system*” can be part of a “device” with the haptic representation system “represent[ing] the sensor input as haptic output.” EX1001, 4:16-19; Fig. 1. Brock’s controller and manipulator, including an obvious actuator, collectively represent non-visible sensor input as haptic output (tactile sensations from haptic actuators) and thus constitute a “*haptic representation system*,” as claimed.

b. [9A]: “a memory configured to store a haptic representation module;”

223. The '546 patent explains that a “haptic representation module” is “software” that “generates a haptic effect that represents received input.” EX1001, 3:8-15.

224. As I discussed above regarding limitation [1PRE], a POSA would have understood that Brock’s “controller” comprises a processor that executes instructions stored in memory to generate a haptic effect. Alternatively, a POSA would have recognized that Brocks’ controller renders obvious the use of instructions stored in memory to generate a haptic effect. Thus, Brock meets, or renders obvious in view of a POSA’s knowledge, limitation [9A].

c. [9B]: “a processor configured to execute the haptic representation module stored on the memory; and”

225. As I discussed above regarding limitation [1PRE], a POSA would have understood that Brock’s “controller” comprises a processor that executes

instructions stored in memory to generate a haptic effect. Alternatively, a POSA would have recognized that Brocks' controller renders obvious the use of such a processor. Thus, Brock meets, and renders obvious in view of a POSA's knowledge, limitation [9B].

d. [9C]: “an actuator configured to output one or more haptic effects;”

226. As I discussed above for limitation [1C], a POSA would have understood that Brock's manipulator comprises an actuator to create a haptic effect. Further, use of an actuator would have been obvious, as actuators were ubiquitous in the prior art for creating haptic effects like vibration. Thus, Brock meets, and renders obvious in view of a POSA's knowledge, limitation [9C].

e. [9D]-[9H]

227. Limitations [9D]-[9H] require the “haptic representation module” of limitation [9B] to perform the steps recited in limitations [1A]-[1E]. Brock thus discloses limitations [9D]-[9H] for the same reasons it discloses limitations [1A]-[1E].

9. Claim 10

228. Claim 10 requires claim 9's “*haptic representation module*” to be configured to perform the functionality of claim 2. As I explained above Brock meets or renders obvious all of the limitations of claims 2 and 9. Brock thus renders claim 10 obvious for the same reasons it renders obvious claims 2 and 9.

10. Claim 11

229. Claim 11 requires claim 9's "*haptic representation system*" to be used with the vibration actuator of claim 3. As I explained above, Brock meets or renders obvious all of the limitations of claims 3 and 9. Brock thus renders claim 11 obvious for the same reasons it renders obvious claims 3 and 9.

11. Claims 13, 21, and 26

230. As I discussed previously, independent claims 13, 21, and 26 largely mirror independent claims 1, 5, and 9. The only distinctions between the two sets of independent claims are: (a) the "*input*" received from a "*sensor*" in limitations [13A], [21A], and [26D] is not limited to "*extra-sensory information*" (ESI) as in limitations [1A], [5A], and [9D], but (b) the "*haptic signal*" and "*haptic effect*" in limitations [13D]-[13E], [21D]-[21E], and [26G]-[26H] are limited to "*at least one of a force haptic signal[/effect], a deformation haptic signal[/effect], or an impedance haptic signal[/effect]*," whereas claims 1, 5, and 9 recite simply a "*haptic signal*" and "*haptic effect*." Claims 13, 21, and 26 are thus broader than claim 1 in sense (a) but narrower in sense (b).

231. Although claims 13, 21, and 26 do not limit the input received from the sensor to ESI, they cover using ESI as I explained previously. Thus, Brock's "non-visible field" is "*input from a sensor*," as recited in claims 13, 21, and 26.

232. Brock discloses using a force haptic effect as an alternative to a vibration haptic effect. *E.g.*, EX1008, [0025] (“The response parameters include...a vibratory device and force feedback to a haptic interface.”), EX1008, [0075] (“reference has been made to the sensing of certain non-visible parameters for the purpose of providing real-time force or vibration feedback to the haptic interface”), EX1008, [0090] (discussing providing “a force feedback to the handle 12”), EX1008, [0100] (“a haptic interface which has the ability of receiving tactile (force or vibration) feedback signals”), Fig. 5, element 140 (“Force Feedback”), claims 30 and 36 (“wherein the tactile signal is at least one of force and vibration”). When Brock discusses “force feedback,” its control signal is a “*force haptic signal*” producing a “*force haptic effect*” as recited in limitations [13D]-[13E], [21D]-[21E], and [26G]-[26H].

233. Because the remaining elements of claims 13, 21, and 26 mirror those of claims 1, 5, and 9, Brock meets them for the same reasons it meets corresponding limitations of claims 1, 5, and 9.

12. Claims 14, 22, and 27

234. Claim 14 depends from independent claim 13. Claim 22 depends from independent claim 21. Claim 27 depends from independent claim 26. Each of claims 14, 22, and 27 limits the “*input*” of their respective independent claims to

“extra-sensory information.” Brock meets this additional limitation for the same reasons it meets limitations [1A], [5A], and [9D].

13. Claims 15, 23, and 28

235. Claim 15 depends from independent claim 13. Claim 23 depends from independent claim 21. Claim 28 depends from independent claim 26. Claims 15, 23, and 28 limit the *“haptic effect”* of their respective independent claims to a *“force haptic effect”* that *“causes a device to apply a force to user.”* A POSA would have understood that Brock’s “force feedback” applies force to a user; thus, Brock renders obvious these claims for the same reason it renders obvious claims 13, 21 and 26.

14. Claim 16

236. Claim 16 depends from claim 15, and limits the *“force haptic effect”* of claim 15 to one that *“causes a device to apply a pressure to the user’s body.”* Pressure is simply force per unit area, which I discussed above. EX1019; EX1020. Brock meets claim 16 for the same reason it meets claim 15.

VI. CONCLUSION

237. I reserve the right to supplement my opinions in the future to respond to any arguments that Patent Owner or its expert(s) may raise and to account for new information as it becomes available to me.

* * *

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: 29 JAN 2024



Gregory F. Welch, Ph.D.

APPENDIX A: MATERIALS CONSIDERED

Exhibit	Description
1001	U.S. Patent No. 9,116,546
1002	Prosecution History of U.S. Patent No. 9,116,546
1003	Declaration of Dr. Gregory Welch (“Welch”)
1004	CV of Dr. Gregory Welch
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 D to Plaintiff’s Preliminary Infringement Contentions, <i>Immersion Corp. v. Valve Corp.</i> , 2:23-cv-00712 (W.D. Wash.) (served Oct. 20, 2023)
1007	Amended Joint Status Report and Discovery Plan, <i>Immersion Corp. v. Valve Corp.</i> , 2:23-cv-00712, Dkt No. 42 (W.D. Wash) (filed Oct. 18, 2023)
1008	U.S. Patent Application Publication No. 2002/0120188 (“Brock”)
1009	U.S. Patent Application Publication No. 2007/0106457 (“Rosenberg”)
1010	U.S. Patent Application Publication No. 2006/0103634 (“Kim”)
1011	U.S. Patent Application Publication No. 2009/0189746 (“Ullrich ’746”)
1012	U.S. Patent Application Publication No. 2010/0253525 (“Engel”)
1013	U.S. Patent Application Publication No. 2010/0283731 (“Grant”)
1014	U.S. Patent Application Publication No. 2011/0046659 (“Ramstein”)
1015	New Oxford American Dictionary, Third Edition (2010), definition of “parameter”
1016	The American Heritage Dictionary, Fifth Edition (2011), definition of “parameter”
1017	Final Written Decision in IPR2016-01372
1018	G. Paschew and A. Richter, “High-resolution tactile display operated by an integrated ‘Smart Hydrogel’ actuator array.” In Y. Bar-Cohen, editor, <i>Electroactive Polymer Actuators and Devices (EAPAD) 2010</i> , Vol. 7642, p. 764234. International Society for Optics and Photonics, SPIE, 2010.
1019	New Oxford American Dictionary, Third Edition (2010), definition of “pressure”
1020	The American Heritage Dictionary, Fifth Edition (2011), definition of “pressure”
1021	U.S. Patent Application Publication No. 2012/0249474 (“Pratt”)

Exhibit	Description
1022	U.S. Patent Application Publication No. 2012/0143182 (“Ullrich ’182”)
1023	New Oxford American Dictionary, Third Edition (2010), definitions of “actuator” and “actuate”
1024	The American Heritage Dictionary, Fifth Edition (2011), definitions of “actuator” and “actuate”
1025	U.S. Patent Application Publication No. 2009/0106655 (“Grant ’655”)
1026	Federal Judicial Caseload Statistics (2024)
1027	Return of Service, Immersion Corp. v. Valve Corp., 2:23-cv-00712, Dkt No. 15 (W.D. Wash) (filed May 19, 2023)

APPENDIX B: U.S. PATENT NO. 9,116,546 CLAIM LIST

Claim 1
[1PRE] A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:
[1A] receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;
[1B] mapping the received input to a haptic signal; and
[1C] sending the haptic signal to an actuator to generate the haptic effect;
[1D] the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and
[1E] the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.
Claim 2
The non-transitory computer-readable medium of claim 1, the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value.
Claim 3
The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.
Claim 4
The non-transitory computer-readable medium of claim 1, wherein the actuator comprises a deformation actuator, and wherein the haptic effect generated by the deformation actuator comprises a deformation haptic effect.
Claim 5
[5PRE] A computer-implemented method for generating a haptic effect, the computer-implemented method comprising:

[5A] receiving input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;
[5B] mapping the received input to a haptic signal; and
[5C] sending the haptic signal to an actuator to generate the haptic effect;
[5D] the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and
[5E] the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.
Claim 6
The computer-implemented method of claim 5, the mapping the received input to the haptic signal further comprising generating the haptic signal when the value of at least one interaction parameter exceeds a specified value.
Claim 7
The computer-implemented method of claim 5, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.
Claim 8
The computer-implemented method of claim 5, wherein the actuator comprises a deformation actuator, and wherein the haptic effect generated by the deformation actuator comprises a deformation haptic effect.
Claim 9
[9PRE] A haptic representation system comprising:
[9A] a memory configured to store a haptic representation module;
[9B] a processor configured to execute the haptic representation module stored on the memory; and
[9C] an actuator configured to output one or more haptic effects;

[9D] wherein the haptic representation module is configured to receive input from a sensor, wherein the input comprises extra-sensory information, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;
[9E] wherein the haptic representation module is further configured to map the received input to a haptic signal;
[9F] wherein the haptic representation module is further configured to send the haptic signal to an actuator to generate the haptic effect;
[9G] wherein the haptic representation module is further configured to modulate the haptic signal when new input is received, wherein the new input comprises an update of at least one value of at least one interaction parameter of the received input; and
[9H] wherein the haptic representation module is further configured to send the modulated haptic signal to the actuator to modulate the generated haptic effect.
Claim 10
The haptic representation system of claim 9, wherein the haptic representation module is further configured to generate the haptic signal when the value of at least one interaction parameter exceeds a specified value.
Claim 11
The haptic representation system of claim 9, wherein the actuator comprises a vibration actuator, and wherein the haptic effect generated by the vibration actuator comprises a vibration haptic effect.
Claim 12
The haptic representation system of claim 9, wherein the actuator comprises a deformation actuator, and wherein the haptic effect generated by the deformation actuator comprises a deformation haptic effect.
Claim 13
[13PRE] A non-transitory computer-readable medium having instructions stored thereon that, when executed by a processor, cause the processor to generate a haptic effect, the generating the haptic effect comprising:
[13A] receiving input from a sensor, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;
[13B] mapping the received input to a haptic signal; and

[13C] sending the haptic signal to an actuator to generate the haptic effect;
[13D] wherein the haptic signal is at least one of a force haptic signal, a deformation haptic signal, or an impedance haptic signal;
[13E] wherein the haptic effect is at least one of a force haptic effect, a deformation haptic effect, or an impedance haptic effect;
[13F] the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and
[13G] the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.
Claim 14
The non-transitory computer-readable medium of claim 13, wherein the input comprises extra-sensory information.
Claim 15
The non-transitory computer-readable medium of claim 13, wherein the haptic effect is a force haptic effect, and wherein the force haptic effect causes a device to apply a force to a user.
Claim 16
The non-transitory computer-readable medium of claim 15, wherein the force haptic effect causes the device to apply pressure to the user's body.
Claim 17
The non-transitory computer-readable medium of claim 13, wherein the haptic effect is a deformation haptic effect, and wherein the deformation haptic effect causes a device to deform.
Claim 18
The non-transitory computer-readable medium of claim 17, wherein the deformation haptic effect causes the device to modify at least one of a macro-shape of the device or a texture of the device, and wherein the deformation of the devices comprises at least one of a visual deformation, a haptic deformation, a quasi-static deformation, or a dynamic deformation.
Claim 21
[21PRE] A computer-implemented method for generating a haptic effect, the computer-implemented method comprising:

[21A] receiving input from a sensor, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;
[21B] mapping the received input to a haptic signal; and
[21C] sending the haptic signal to an actuator to generate the haptic effect;
[21D] wherein the haptic signal is at least one of a force haptic signal, a deformation haptic signal, or an impedance haptic signal;
[21E] wherein the haptic effect is at least one of a force haptic effect, a deformation haptic effect, or an impedance haptic effect;
[21F] the mapping the received input to the haptic signal further comprising modulating the haptic signal when new input is received, wherein the new received input comprises an update of at least one value of at least one interaction parameter of the received input; and
[21G] the sending the haptic signal to the actuator to generate the haptic effect further comprising sending the modulated haptic signal to the actuator to modulate the generated haptic effect.
Claim 22
The computer-implemented method of claim 21, wherein the input comprises extra-sensory information.
Claim 23
The computer-implemented method of claim 21, wherein the haptic effect is a force haptic effect, and wherein the force haptic effect causes a device to apply a force to a user.
Claim 24
The computer-implemented method of claim 21, wherein the haptic effect is a deformation haptic effect, and wherein the deformation haptic effect causes a device to deform.
Claim 26
[26PRE] A haptic representation system comprising:
[26A] a memory configured to store a haptic representation module;
[26B] a processor configured to execute the haptic representation module stored on the memory; and
[26C] an actuator configured to output one or more haptic effects;

[26D] wherein the haptic representation module is configured to receive input from a sensor, wherein the input further comprises one or more interaction parameters, and wherein each interaction parameter comprises a value;
[26E] wherein the haptic representation module is further configured to map the received input to a haptic signal;
[26F] wherein the haptic representation module is further configured to send the haptic signal to an actuator to generate the haptic effect;
[26G] wherein the haptic signal is at least one of a force haptic signal, a deformation haptic signal, or an impedance haptic signal;
[26H] wherein the haptic effect is at least one of a force haptic effect, a deformation haptic effect, or an impedance haptic effect;
[26I] wherein the haptic representation module is further configured to modulate the haptic signal when new input is received, wherein the new input comprises an update of at least one value of at least one interaction parameter of the received input; and
[26J] wherein the haptic representation module is further configured to send the modulated haptic signal to the actuator to modulate the generated haptic effect.
Claim 27
The haptic representation system of claim 26, wherein the input comprises extra-sensory information.
Claim 28
The haptic representation system of claim 26, wherein the haptic effect is a force haptic effect, and wherein the force haptic effect causes a device to apply a force to a user.
Claim 29
The haptic representation system of claim 26, wherein the haptic effect is a deformation haptic effect, and wherein the deformation haptic effect causes a device to deform.