UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.; AND
SAMSUNG ELECTRONICS AMERICA, INC.,
Petitioner

v.
OURARING, INC.,
Patent Owner

Case No. PGR2024-00031
U.S. Patent No. 11,868,179

DECLARATION OF DR. BRIAN W. ANTHONY IN SUPPORT OF PETITION FOR POST-GRANT REVIEW OF U.S. PATENT NO. 11,868,179

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Petitioner Samsung Ex-1002, 0003

I. INTRODUCTION

1. I have been retained by Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively, "Samsung" or "Petitioner"), as an independent expert in this proceeding before the Patent Trial and Appeal Board ("PTAB" or "Board"). I understand that Samsung is requesting that the Board institute a post-grant review ("PGR") proceeding of U.S. Patent No. 11,868,179 ("the '179 Patent") (Ex 1001), currently assigned to Ouraring, Inc., ("Patent Owner" or "PO").

2. I am not and have never been an employee of Samsung. I am being compensated at my usual and customary rate of $500 per hour. No part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my independent analysis of the '179 Patent in light of the prior art publications cited below. I have also been asked to consider the state of the art and prior art available as of November 29, 2013. Based on the prior art discussed in this declaration, it is my opinion that Claims 1-16 of the '179 Patent are unpatentable for the reasons provided below.

A. Qualifications

4. As indicated in my *curriculum vitae* ("CV"), included as Ex-1003, I am currently a Principal Research Scientist at the Massachusetts Institute of

Technology ("MIT"). My CV includes additional information about my professional history and contains further details on my experience, publications, patents, and other qualifications to render an expert opinion. Herein, I highlight experiences relevant to the technology of the patent at issue.

5. I earned a Bachelor of Science in Engineering from Carnegie Mellon University in 1994 and a Master's degree in Engineering from MIT in 1998. My thesis topic related to anisotropic wave guides and acoustic non-destructive testing. In 2006, I earned my Ph.D. in Engineering from MIT. My research focused on high-performance computation, signal processing, and electro-mechanical system design.

6. In 1997, I co-founded Xcitex Inc., a company that specialized in video-acquisition and motion-analysis software. I served as the Chief Technology Officer and directed and managed product development until 2006. Our first demo-product was an optical ring for human motion measurement used to capture user hand motion in order to control the user's interaction with a computer. Many of the structural elements of our optical ring—developed nearly a decade prior to the '179 Patent's earliest possible priority date—addressed the same system issues as those described and claimed in the '179 Patent. For example, our optical ring included optical structures for light blocking, light redirection, and light capture. We estimated human hand-motion based on how that motion changed the detected

light. In our application we did not try to eliminate motion artifact, we tried to measure it. In developing our ring, we considered well-known problems such as extraneous light and motion, which are, unsurprisingly, also discussed in the '179 Patent.

7. I joined MIT in 2006 and have been the Director of the Master of Engineering in Advance Manufacturing and Design Program for over ten years. The degree program covers four main components–Manufacturing Physics, Manufacturing Systems, Product Design, and Business Fundamentals. Many of the courses, projects, and papers my students undertake involve technologies relevant to the '179 Patent, for example, sensor devices including non-invasive biosensors.

8. In 2011, I co-founded MIT's Medical Electronic Device Realization Center ("MEDRC") and currently serve as co-director. I am also the Director Technical Operation of the Center for Clinical and Translational Research (CCTR) at the Institute of Medical Engineering & Science, and Associate Director of MIT.nano at MIT. The MEDRC aims to create and deploy revolutionary medical technologies by collaborating with clinicians, the microelectronics, and medical devices industries. We combine expertise in computation; communications; optical, electrical, and ultrasound sensing technologies; and consumer electronics. We focus on the usability and productivity of medical devices using, for example,

image and signal processing combined with intelligent computer systems to enhance practitioners' diagnostic intuition. Our research portfolio includes low power integrated circuits and systems, big data, micro electro-mechanical systems, bioelectronics, sensors, and microfluidics. Specific areas of innovation include wearable, non-invasive and minimally invasive optical biosensor devices, medical imaging, laboratory instrumentation, and the data communication from these devices and instruments to healthcare providers and caregivers. My experience with these devices is directly applicable to the technology in the '179 Patent. For example, one current project related to this work is in laser-ultrasound imaging and tissue characterization. In this work, an eye and skin safe pulsed laser beam is directed at the body and reflected and transmitted signals are used to map internal tissue structures. In another current project, we use a patient-mounted mobile near infrared (NIR) camera to image and characterize the surface and subsurface structures of the skin.

9. Furthermore, my research focuses on computational instrumentation, including the development of instrumentation and measurement solutions for manufacturing systems and medical devices. Additionally, my teaching interests include the design and modeling of large-scale systems in a wide variety of decision-making domains and developing optimization algorithms and software for analyzing and designing such systems. I teach or have taught courses in Electrical

Engineering, Controls, Optics, Communications, and Signal Processing, all pertinent subject matter to the '179 Patent. I teach or have taught courses in Manufacturing Engineering, Smart Manufacturing, Industrial Internet of Things all pertinent subject matter to the '179 Patent.

10. I also co-founded the Center for Polymer Micro-fabrication at MIT. The Center's research focuses on polymer-based manufacturing processes and the large-scale commercialization of micro fluidic devices for chemical, biomedical, and photonic applications. My experience under these initiatives is directly applicable to the technology in the '179 Patent. We develop polymer based devices and sensors and use noninvasive monitoring techniques during the manufacturing process.

11. I have published approximately 100 papers, and have received a number of best paper and distinguished paper awards. I am a co-author of a number of papers that relate to the technology in the '179 Patent, such as:

- Ranger, Bryan J.; Feigin, Micha; Pestrov, Nikita; Zhang, Xiang; Lempitsky, Victor; Herr, Hugh M.; Anthony, Brian W., "Motion compensation in a tomographic ultrasound imaging system: Toward volumetric scans of a limb for prosthetic socket design," 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 7204-7207;

- Shih-Yu Sun, Matthew Gilbertson, and Brian W. Anthony, "Probe Localization for Freehand 3D Ultrasound by Tracking Skin Features," Book Section, Medical Image Computing and Computer-Assisted Intervention, MICCAI 2014, Springer, 2014, Vol. 8674. Lecture Notes in Computer Science, pp. 365-372;
- J. H. Lee, C. M. Schoellhammer, G. Traverso, D. Blankschtein, R. Langer, K. E. Thomenius, D. S. Boning, B. W. Anthony, "Towards Wireless Capsule Endoscopic Ultrasound (WCEU)," IEEE International Ultrasonics Symposium (IUS), Chicago, IL, 2014, pp. 734-737; and
- Zakrzewski, A., Anthony, B. W., "Quantitative Elastography and its Application to Blood Pressure Estimation: Theoretical and Experimental Results," 2013 IEEE Engineering in Medicine and Biology Society (EMBC), pp. 1136-1139.

B. Materials Considered

12. In forming my opinions, I reviewed the following documents, in addition to others I have cited in my declaration. I also relied on my own knowledge of and experience in the field of mechanical engineering, biomedical engineering, optical engineering, the development of physiological monitoring devices such as non-invasive biosensors, sensor system design and signal

processing.

Ex. No.	Description
Ex-1001	U.S. Patent No. 11,868,179 ("the '179 Patent)
Ex-1004	Prosecution History of U.S. Patent No. 11,868,179
Ex-1005	U.S. Patent Publication No. 20120016245 to Niwa ("Niwa")
Ex-1006	U.S. Patent No. 8,954,135 to Yuen ("Yuen")
Ex-1007	U.S. Patent No. 10,303,867 to Schröder ("Schröder")
Ex-1008	Certified Translation of DE 102013012339.9 to Schröder
Ex-1009	Original DE 102013012339.9 to Schröder
Ex-1010	INTENTIONALLY LEFT BLANK
Ex-1011	INTENTIONALLY LEFT BLANK
Ex-1012	INTENTIONALLY LEFT BLANK
Ex-1013	INTENTIONALLY LEFT BLANK
Ex-1014	INTENTIONALLY LEFT BLANK
Ex-1015	INTENTIONALLY LEFT BLANK
Ex-1016	INTENTIONALLY LEFT BLANK
Ex-1017	INTENTIONALLY LEFT BLANK
Ex-1018	INTENTIONALLY LEFT BLANK
Ex-1019	INTENTIONALLY LEFT BLANK
Ex-1020	Claim Mapping Table
Ex-1021	*Oura Health Oy v. Circular SAS*, No. 22-cv-00478-ADA, Dkt. No. 45 (W.D. Tex. Feb. 2, 2024) (Claim Construction Order)

Ex. No.	Description
Ex-1022	*Dynamic Drinkware*-type analysis for Schröder
Ex-1023	Dynamic Drinkware-type analysis for Mestas
Ex-1024	U.S. Patent No. 4,830,014 to Goodman ("Goodman")
Ex-1025	U.S. Patent No. 6,745,061 to Hicks ("Hicks")
Ex-1026	U.S. Patent No. 7,190,986 to Hannula ("Hannula")
Ex-1027	Volker Konig et al., Reflectance Pulse Oximetry – Principles and Obstetric Application in the Zurich System, 14 Journal of Clinical Monitoring (Aug. 1998) ("Konig")
Ex-1028	U.S. Patent No. 6,608,562 to Kimura ("Kimura")
Ex-1029	Kevin K. Tremper et al., Pulse Oximetry, 70 Journal of American Society of Anesthesiologists, Inc. (Jan. 1989) ("Tremper")
Ex-1030	Y. Mendelson et al., A Wearable Reflectance Pulse Oximeter for Remote Physiological Monitoring, Proceedings of 28th IEEE EMBS Annual Int'l Conference (Aug. 30-Sept. 3, 2006) ("Mendelson 2006")
Ex-1031	Sokwoo Rhee et al., Artifact-Resistant, Power-Efficient Design of Finger-Ring Plethysmographic Sensors Part I: Design and Analysis, IEEE (2000) ("Rhee 2000 Part I")
Ex-1032	Sokwoo Rhee et al., Artifact-Resistant, Power-Efficient Design of Finger-Ring Plethysmographic Sensors Part II: Prototyping and Benchmarking, IEEE Proceedings of 22nd Annual EMBS Int'l Conference (July 23-28, 2000) ("Rhee 2000 Part II")
Ex-1033	Sokwoo Rhee et al., Artifact-Resistant Power-Efficient Design of Finger-Ring Plethysmographic Sensors, 48 IEEE Transactions of Biomedical Engineering (July 2001) ("Rhee 2001")
Ex-1034	U.S. Patent No. 6,699,199 to Asada ("Asada '199")

Ex. No.	Description
Ex-1035	Sokwoo Rhee, Design and Analysis of Artifact-Resistive Finger Photoplethysmographic Sensors for Vital Sign Monitoring, MIT (June 2000) ("Rhee Thesis 2000")
Ex-1036	C.T. Olofson et al., Machining of Titanium Alloys (1965) ("Olofson")
Ex-1037	Asada et al., Mobile Monitoring with Wearable Photoplethysmographic Biosensors, IEEE Eng'g in Medicine & Biology Magazine 28 (May-June 2003) ("Asada 2003")
Ex-1038	Denisse Castaneda et al., A review on wearable photoplethysmography sensors and their potential future applications in health care, Int J Biosens Bioelectron. 2018 ("Wearable photoplethysmography sensors")
Ex-1039	U.S. Patent No. 7,468,036 to Rulkov ("Rulkov")
Ex-1040	U.S. Patent Publication No. 2006/0211924 ("Dalke")
Ex-1041	Guidelines to Enhancing the Heart-Rate Monitoring Performance of Biosensing Wearables
Ex-1042	U.S. Patent No. 4,880,304 to Jaeb ("Jaeb")
Ex-1043	Tom Lister et al., Optical Properties of Human Skin, Journal of Biomedical Optics (September 2012) ("Optical Properties")
Ex-1044	John G. Webster, *Design of Pulse Oximeters*, CRC Press (1997)
Ex-1045	U.S. Patent Publication No. 20130211291 to Tran ("Tran")
Ex-1046	WO 2001/017421A1 to Lindberg ("Lindberg")
Ex-1047	WO 2011/132009 to Nyiradi ("Nyiradi")
Ex-1048	U.S. Patent Application Publication No. 2014/0361945 to Misra et al. ("Misra")

Ex. No.	Description
Ex-1049	U.S. Patent Application Publication No. 2014/0361934 to Ely et al. ("Ely")
Ex-1050	European Patent No. 2281205 (Chen)
Ex-1051	Lawrence K. Au et al., *Episodic Sampling: Towards Energy-Efficient Patient Monitoring with Wearable Sensors*, Annual International Conference of the IEEE Engineering in Medicine and Biology Society (2009)
Ex-1052	Anastasios Petropoulos et al., *Flexible PCB-MEMS flow sensor*, Procedia Engineering 47 236-239 (2012) ("Petropoulos")
Ex-1053	Tianjia Sun et al., *Wireless Power Transfer for Medical Microsystems*, Springer (2013) ("Sun")
Ex-1054	U.S. Patent Pub. No. 2014/0187160 to Prencipe ("Prencipe")
Ex-1055	H. Ardebili and Michael G. Pecht, *Encapsulation Technologies for Electronic Applications*, William Andrew (2009) ("Ardebili")
Ex-1056	Ciprian Ciofu et al., Injection and Micro Injection of Polymeric Plastics Materials: A Review, Int'l J. Modern Mfg. Techs. 49 (2013)
Ex-1057	Richard J. Ross, LCP Injection Molded Packages—Keys to JEDEC 1 Performance, IEEE, 2004 Electronic Components and Technology Conference 1807 (2004)
Ex-1058	Tadamoto Sakai, Encapsulation Process for Electronic Devices Using Injection Molding Method, 12 Advances in Polymer Technology 61 (1993)
Ex-1059	N.J. Teh et al., Embedding of Electronics within Thermoplastic Polymers using Injection Moulding Technique, IEEE, 2000 Int'l Electronics Manufacturing Technology Symposium 10 (2000)
Ex-1060	U.S. Patent No. 6,201,698 to Hunter ("Hunter")

Ex. No.	Description
Ex-1061	U.S. Patent No. 4,012,629 to Simms ("Simms")

II. LEGAL STANDARDS

13. In forming my opinions and considering the subject matter of the '179 Patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below

14. I understand that earlier publications and patents may act to render a patent unpatentable for one of two reasons: (1) anticipation, and (2) obviousness.

A. Anticipation

15. As explained to me by counsel, it is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in the reference. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily present in the allegedly anticipating reference, and that it would have been so recognized by a person of ordinary skill in the art ("POSITA").

16. I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

17. Although anticipation typically involves the analysis of a single prior

art reference, I understand that additional references may be used to show that the prior art reference has enabling disclosure (i.e., allows a POSITA to make the invention without undue experimentation), to explain the meaning of a term used in the prior art reference, and/or to show that a characteristic is inherent in the prior art reference.

B. Obviousness

18. As explained to me by counsel, I understand that a claim is invalid as obvious if it would have been obvious to a person of ordinary skill in the art at the time the alleged invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a person of ordinary skill in the art who was aware of the prior art would have been able to come up with the claimed invention. This may be the case, for example, where the missing element represents only an insubstantial different over the prior art or a reconfiguration of a known system. I understand that in an obviousness determination, the person of ordinary skill in the art is presumed to have knowledge of all material prior art.

19. I understand that an obviousness analysis requires an understanding of the scope and content of the prior art, any differences between the alleged invention and the prior art, and the level of ordinary skill in evaluating the pertinent art.

20. I understand that when a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation, obviousness likely bars its patentability. For the same reason, if a technique has been used to improve one device and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

21. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determine from the perspective of a person of ordinary skill in the art at the time of the alleged invention. I have been told that there is not requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered through the knowledge of one skilled in the art. In addition, I have been told that the inferences and creative steps a person of ordinary skill in the art would employ are relevant to the determination of obviousness.

22. I understand that one may consider, e.g., whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of

elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a person of ordinary skill in the art.

23. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of those having ordinary skill in the art at the time of the invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I understand that there must be a nexus—that is, a connection—between any such secondary considerations and the

alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness.

24. I am not aware of any allegations by the named inventor of the '179 Patent or any assignee of the '179 Patent that any secondary considerations tend to rebut the obviousness of the '179 Patent.

25. Additionally, I understand that in considering obviousness, it is important not to use the benefit of hindsight derived from the patent under consideration.

C. Level of Ordinary Skill in the Art

26. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to that patent, as well as the level of ordinary skill in that art at the time of the claimed invention. The "art" is the field of technology to which the patent is related.

27. I am informed and understand that the POSITA is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor's skill is not determinative of the level of ordinary skill. I further understand that factors that may be considered in determining level of skill include: (i) the types of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in

the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

28. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

29. A person of ordinary skill in the art at the relevant time, which I have been told to consider as November 29, 2013 ("POSITA") would have had at least a four-year degree in electrical engineering, mechanical engineering, biomedical engineering, optical engineering, or related field of study, or equivalent experience, and at least two years' experience in academia or industry studying or developing physiological monitoring devices such as non-invasive biosensors. A POSITA would have also been familiar with, for example, sensor system design and signal processing. A higher level of education or skill might make up for less experience, and vice versa.

30. Based on my knowledge, skill, and experience, I have an understanding of the capabilities of a person of ordinary skill in the relevant art. For example, from my industry experience, I am familiar with what an engineer designing non-invasive biosensors would have known and found predictable in the art. From teaching and supervising my post-graduate students, I also have an understanding of the knowledge that a person with this academic experience

possesses. Furthermore, I possessed the knowledge of a POSITA myself at least as of 1997.

D. Claim Construction

31. I understand that the United States Patent and Trademark Office interprets claim terms in an *inter partes* review proceeding under the same claim construction standard that is used in a United States federal court. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

32. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by one of ordinary skill in the art in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claims terms are generally not limited by the embodiments described in the specification.

33. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have been informed that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

III. SUMMARY OF GROUNDS

Ground	Summary
1	Claims 1-5 and 11-16 are obvious by Niwa (Ex-1005).
2	Claims 6-10 are obvious by Niwa in view of Yuen (Ex-1006).
3	Claims 15-16 are obvious by Niwa in view of Schröder (Ex-1007).
4	Claims 1-12 are obvious by Yuen.
5	Claims 1-10, 13-16 are obvious by Yuen in view of Schröder.
6	Claims 11-12 are obvious by Yuen in view of Niwa.

IV. THE '179 PATENT

A. Overview of the '179 Patent

34. The '179 Patent relates to wearable computing devices (WCD) that monitors activity within the wearer's body. Ex-1001, 1:39-40. As shown in Figure 3, the WCD can take the form of a ring, but can also take the form of a bracelet or other wearable accessory that is worn close to the skin. *Id*., 8:66-9:7.

35. As shown in Figure 2, WCD 110 includes "a processor module 210, a plurality of sensor modules 220, a status indicator module 230, a power generation and management module 240, a communication module 250, a memory 260, and miscellaneous modules 270." Ex-1001, 10:19-23.

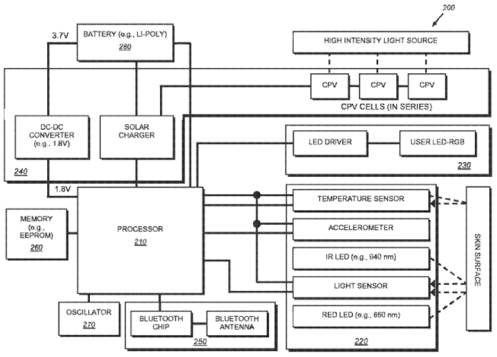


FIG. 2

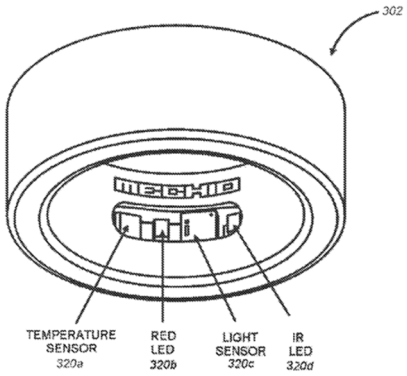


FIG. 3B

Id., Figs. 2, 3B.

36. The ’179 Patent states that the wearing computer device comprises sensor modules which can include various temperature and LED sensors. Ex-1001, 11:13-16. As shown in Figure 3B, “those sensors (e.g., sensors 320 a-320 d) which are directly related to biological sign monitoring can be configured and positioned in a way that is close to the skin (e.g., facing the interior window 130 of the WCD 110).” *Id*., 11:16-20.

37. As discussed in further detail below, the challenged claims are obvious over prior art describing the same capabilities.

B. Prosecution History of the ’179 Patent

38. I understand that the ’179 Patent was filed on May 24, 2023, and claims priority to a series of continuations and divisional applications to provisional App. No. 61/910,201 filed November 29, 2013. Ex-1001, Cover. The patent was granted prioritized examination and a first action Notice of Allowance

was issued on September 21, 2023. *Id*., 0155, 1170.

39. I further understand that my Declaration presents arguments not considered during prosecution of the '179 Patent.[1]

V. TECHNOLOGY BACKGROUND

A. Wearable Electronic Devices Were Known

40. Wearable electronic devices, along with the various design challenges they posed and the solutions proposed to address these challenges, were well-known to a POSITA by 2013. For example, it was known by 2013 that wearable photoplethysmographic biosensors could be used for the monitoring, diagnosis, and treatment of major and chronic diseases "by providing information enabling precise titration of therapy or detecting lapses in patient compliance." Ex-1037, 28 (Asada 2003). Wearable biosensor devices were known to be useful in "sensing untreated elevated blood pressure" and "trigger[ing] an automated reminder for the patient to take…medication." Ex-1037, 28 (Asada 2003); *see also* Ex-1030, 912 (Mendelson 2006) ("[T]he emerging development of compact, low-power, small-size, light-weight, and unobtrusive wearable devices may facilitate remote noninvasive monitoring of vital signs[.]").

[1] Counsel has advised me that the Yuen reference (Ex-1006) was cited on an IDS with 139 other references (Ex-1004, 0632-0638) but not used in a rejection during prosecution. Counsel has further advised me that the Examiner's Office Actions and Notice of Allowance are silent on Yuen's teachings. It is my opinion that Yuen's teachings renders Claims 1-16 obvious for the reasons discussed below.

41. Wearable electronic devices in the form of a finger-ring structure were also known by 2013. For example, Harry Asada and his group at MIT developed a ring sensor by 2003 that was "capable of reliably monitoring a patient's heart rate, oxygen saturation, and heart rate variability." Ex-1037, 28 (Asada 2003); *see also* Ex-1034, 1:20-24 (Asada '199) ("Finger-ring sensors may be employed, for example, for monitoring such physiological parameters as blood flow, blood constituent concentration, and pulse rate, all of which may be measured by other means that are more cumbersome, and thus less comfortable, to a patient."), 2:51-56 ("For purposes of the present description, the sensor will be referred to, without limitation, as a ring sensor, and the sensing modality, again without limitation, will be described in terms of a photoplethysmographic device for measuring a pulse using optical elements such as infrared light-emitting diodes (LEDs) and photodiodes."). The prototypes of Asada's finger-ring as of 2003 are depicted below. Ex-1037, Figs. 9-10, 15 (Asada 2003).

Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

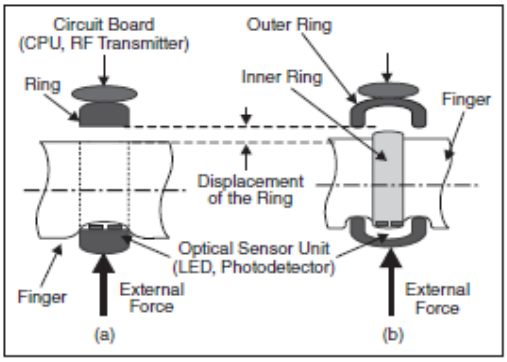


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force [31].

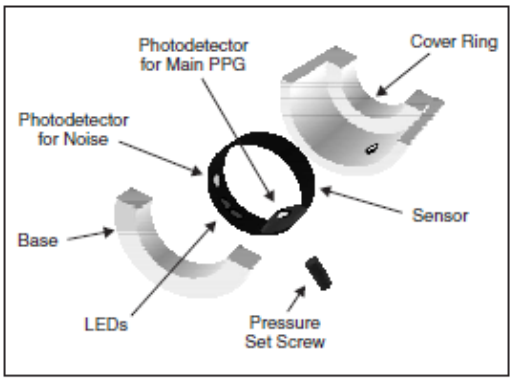


Fig. 15. The schematic of the Prototype C ring sensor.

42. Asada explains the motivations for implementing a wearable electronic device in the form of a ring, noting that "[c]ompactness, stability of signal, motion and other disturbance rejection, durability, data storage and transmission, and low power consumption" are "major design considerations." Ex-1037, 28 (Asada 2003). He further notes that "[i]t is imperative that they are simple to use and comfortable to wear for long periods of time." Ex-1037, 28 (Asada 2003). Moreover, he explains that "[s]ince continuous monitoring requires a device that must be noninvasive and worn at all times, a ring configuration for the sensor unit is a natural choice" because of its "low weight and small size," and "rings are generally worn without removal more often than watches." Ex-1037, 28 (Asada 2003). He also notes that recent studies "indicated that the finger is one of the best places for WBS sensor attachment" because "[t]he primary vasculature of the finger is located near the surface and therefore makes it optimal for monitoring arterial blood flow using noninvasive optoelectronic sensors," thus making it "ideal for long-term measurements." Ex-1037, 30 (Asada 2003); *see also* Ex-1034, 1:20-

24 (Asada '199) ("A sensor worn as a finger ring sensor has particular advantages since a ring sensor may be worn by the patient at all times, hence the health status may be monitored 24 hours a day.").

43. Asada explains that "[a]n obvious source of signal corruption results from the direct interaction of the sensor unit with the wearer's surrounding environment; e.g., holding objects, touching surfaces, etc." Ex-1037, 34 (Asada 2003). Therefore, "the body of the ring must separate the sensor unit in order to decouple the sensor unit from these interactions." Ex-1037, 34 (Asada 2003). He therefore designed and implemented "a double ring configuration" such that "[t]he disturbance force is born by the outer ring and is not transmitted to the inner ring holding the sensor unit" and "the outer ring serves as an optical shield for protecting the sensor unit from the ambient light." Ex-1037, 34 (Asada 2003).

44. Asada and his group also built and field-tested a transmittal photo-plethysmograph ("PPG") ring sensor "[t]o improve motion artifact resistance and accuracy." Ex-1037, 35 (Asada 2003). He redesigned a sensor band using "bio-compatible elastic materials to better hold the LED[s] and PD[s], maintain a proper level of pressure, optically shield the sensor unit, and secure the contact with the skin consistently in the face of finger motion," resulting in a stable transmittal PPG. Ex-1037, 35 (Asada 2003); *see also* Ex-1028, 1:13-16 (Kimura) ("This invention relates to a vital signal detecting apparatus for detecting a vital signal,

having an attachable device to be attached for example to a finger, an ear, an arm, a leg, torso or a neck of a human subject.").

45. Harry Asada's graduate student, Sokwoo Rhee, also authored a thesis and a number of articles between 2000 and 2001 detailing the design, analysis, prototyping, and benchmarking of finger-ring plethysmographic sensors. *See, e.g.*, Ex-1031 (Rhee 2000 Part I); Ex-1032 (Rhee 2000 Part II); Ex-1033 (Rhee 2001); Ex-1035 (Rhee Thesis 2000). Specifically, Rhee developed and presented "[a] miniaturized, telemetric, photoplethysmography sensor for long-term, continuous monitoring," called "a 'ring-sensor,'" which "is attached to a finger base for monitoring beat-to-beat pulsation, and the data is sent to a host computer via a RF transmitter." Ex-1031, 1 (Rhee 2000 Part I); Ex-1032, 2796 (Rhee 2000 Part II); Ex-1033, 795 (Rhee 2001); Ex-1035, 14 (Rhee Thesis 2000). "The ring sensor is a miniaturized, telemetric, monitoring device worn by a patient as a finger ring." Ex-1031, 1 (Rhee 2000 Part I); Ex-1035, 14 (Rhee Thesis 2000) (same); Ex-1033, 796 (Rhee 2001) ("This miniaturized sensor in a ring configuration is a rational design choice for 24-h continuous monitoring, since a finger ring is probably the only thing that a majority of people will be willing to wear at all times.").

46. Rhee's thesis and papers address two major design issues: "one is to minimize motion artifact and the other is to minimize the consumption of battery power." Ex-1031, 1 (Rhee 2000 Part I); Ex-1033, 795 (Rhee 2001); Ex-1035, 2

(Rhee Thesis 2000). "An efficient double ring design is developed to lower the influence of external force, acceleration, and ambient light, and to hold the sensor gently and securely on the skin, so that the circulation at the finger may not be obstructed." Ex-1031, 1 (Rhee 2000 Part I); Ex-1033, 795 (Rhee 2001); Ex-1035, 2 (Rhee Thesis 2000). The structural details of Rhee's finger-ring sensor are discussed in more detail in the sections below.

1. Photoplethysmography (PPG) sensors were well known

47. A plethysmograph is a device used to measure changes in volume within the body or a specific organ. This measurement can be applied in various medical contexts to monitor and diagnose conditions related to blood flow, respiratory function, and other physiological parameters.

48. One specific type of plethysmograph is the photo-plethysmograph (PPG), which utilizes optical techniques to detect blood volume changes in the microvascular bed of tissue. PPG devices typically use a light source and a photodetector to measure the variations in light intensity as it is transmitted through or reflected off the tissue. These variations are caused by the pulsatile nature of blood flow, hence the name "plethysmograph," referring to the measurement of volume changes.

49. Photoplethysmography (PPG) is a well-known optical measurement method for monitoring heart rate. Ex-1038. Popularity around using PPG

technology as an alternative to heart rate monitoring techniques have increased "due to the simplicity of its operation, the wearing comfort ability for its users, and its cost effectiveness." *Id*., 0002. Wearable PPG sensors can be placed at the body locations. *Id*., 0003, 0014, Fig. 1.

50. PPG uses "a light source and a photodetector at the surface of skin to measure the volumetric variations of blood circulation." *Id*., 0001. "The light source emits light to a tissue and the photodetector measures the reflected light from the tissue." *Id*., 0003. Atypical PPG sensors emit light to "detect cardiovascular diseases." *Id*., 0005. The most common LED colors used are red and green while some studies have also used yellow. *Id*. PPG also utilizes "infrared light to measure the volumetric variations of blood circulation" which provides information about the user's cardiovascular system. *Id*., 0002. Near-infrared light can also be used for early detection of physiological parameters such as cardiovascular diseases. *Id*. This is because "[l]ight with longer wavelengths penetrates more deeply into the tissue." *Id*., 0005. However, infrared light is more susceptible to motion artifacts caused by "movement of the PPG sensor over the tissue, skin deformation, blood flow dynamics, and ambient temperature." *Id*. In that instance, green LEDs have a shorter wavelength and may be a better option. *Id*. Thus, a POSITA would have understood it would have been beneficial to use both visible LEDs and infrared LEDs to gather various physiological data helpful

to the user.

2. Beer's Law

51. Beer's Law describes the relationship between the absorbance of light by a substance and its concentration. The equation is: $A=\varepsilon \cdot b \cdot c$. Where: (A) represents the absorbance of light. (ε) is the molar absorptivity (a constant specific to the substance). (b) is the path length (the distance the light travels through the sample). (c) is the concentration of the absorbing substance.

52. Beer's law "describes the attenuation of light traveling through a uniform medium containing an absorbing substance." Ex-1044 (WebsterDesign), 0054, Fig. 4.1. "Pulse oximeters determine the oxygen saturation of arterial blood by measuring the light absorbance of living tissue at two different wavelengths and using the arterial pulsation to differentiate between absorbance of arterial blood and other absorbers." *Id*., 0058. For example, when light from LEDs enters the tissue, it is scattered by both the moving red blood cells and the nonmoving tissue, and a part of this back scattered light is detected by the photodiode. *Id*., 0102. The output of the photodiode is processed by the pulse oximeter and measures the oxygen saturation of the pulsatile blood. *Id*.

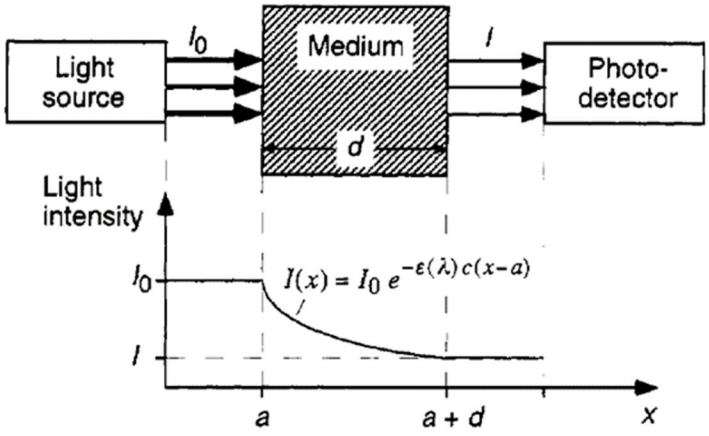


Figure 4.1 Beer's law: Incident light of intensity I_0 travels the distance a from a light source to the medium without being absorbed in the air. The light intensity decreases exponentially with distance in the absorbing medium. The intensity of the transmitted light I is determined by Beer's law. It stays constant after exiting the medium with optical path length d and can be measured by a photodetector.

53. The measured amount of oxygen in the blood differ from the results of the Beer's law theory because Beer's law does not assume light scattering but light scattering highly increases the absorbance of light. *Id*., 0066. The skin surface, tissue, muscle, bone, and blood of the user causes light scattering which increases the absorbance of light. *Id*., 0065. The intensity of the light scattered by the tissue "depends on such factors as the red blood cell concentration in the blood; on the size, shape, orientation, and index of refraction of the scattering particles; on the tissue thickness; and on the aperture cone of the detector." *Id*., 0066. Further, the scattering effects of the light passing through blood depend on the wavelength of the light and the oxygen saturation. *Id*., 0067.

3. Optical properties of human tissue

54. There are two biomolecules considered to dominate the absorption of visible light in skin: hemoglobin and melanin. Ex-1043 (Optical Properties), 0001. Hemoglobin is the dominant absorber of light in the dermis. *Id*. Melanin is a family of biomolecules that provide pigment to skin. *Id*., 0001, Fig. 1. Melanin is generally contained within the "epidermis and produce[s] an absorption spectrum that gradually decreases from the ultraviolet (UV) to the infrared (IR) regions." *Id*., 0001. The optical properties of this layer result in absorption and scattering of light, which are characterized by the absorption and scattering coefficients. *Id*., 0003. The absorption coefficient "characterizes the average number of absorption events per unit path length of photons traveling in the tissue." Ex-1041 (Guidelines to enhancing), 0002. The absorption coefficient can also be calculated as a function of wavelength.

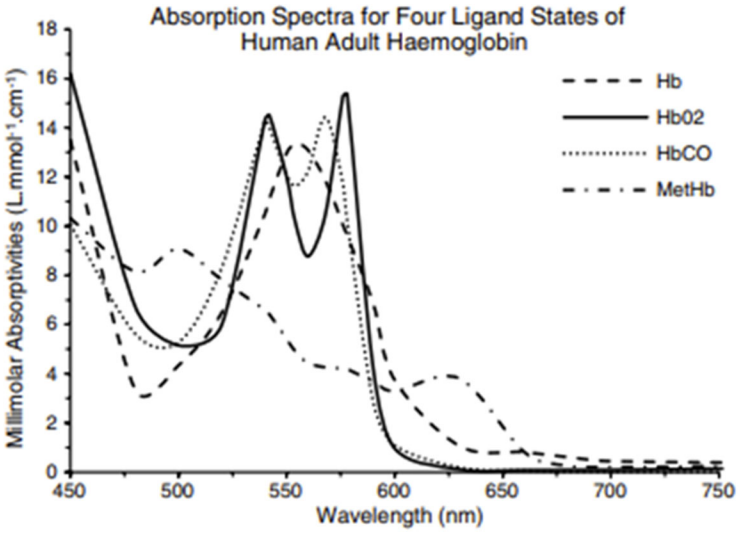


Fig. 1 Absorption spectra of deoxyhemoglobin (Hb), oxyhemoglobin (HbO_2), carboxyhemoglobin (HbCO), and methemoglobin (MetHb) in the visible region, from Ref. 27.

55. As shown in Figure 1, the peak absorption coefficients correspond to wavelengths around 540nm and 570nm. *Id*., 0003. At the wavelength of around 540nm and 570nm, "the absorption change due to the blood volume change is the greatest and the photodiode measures the strongest pulsate signal." *Id*.

4. Pulse oximetry and oxygen saturation (SpO2)

56. Pulse oximetry measures peripheral arterial oxygen saturation (SpO_2) as an indicator of tissue oxygenation. How it works: Light at two different wavelengths (for example, 660 nm and 940 nm) illuminates oxygenated (oxyhemoglobin) and deoxygenated hemoglobin (deoxyhemoglobin) in blood. The ratio of light absorbance between these two forms of hemoglobin is calculated. This ratio is compared with previously calibrated direct measurements of arterial

oxygen saturation (SaO_2) to estimate peripheral SpO_2.

57. The calculation of arterial oxygen saturation (SpO2) using a PPG involves analyzing the photoplethysmography signal, which comprises both alternating current (AC) and direct current (DC) components. The AC component represents the pulsatile part of the signal, corresponding to the cardiac cycle, while the DC component represents the non-pulsatile part, including constant tissue and venous blood absorption.

58. To calculate SpO2, the ratio of the AC to DC components of the PPG signal at two different wavelengths (typically red and infrared) is used. This ratio is indicative of the relative absorption of light by oxygenated hemoglobin (Oxy-Hb) and deoxygenated hemoglobin (Deoxy-Hb). By comparing these ratios at the two wavelengths, the proportion of Oxy-Hb to Deoxy-Hb can be determined.

59. The formula for calculating SpO2 is derived from this ratio, often expressed as: SpO2 = (Oxy-Hb) / (Oxy-Hb+Deoxy-Hb) ×100%.

5. Transmission of light as compared to the reflection of light

60. Light interacting with tissue at the microscale (wavelength scale) undergo absorption, reflection, or transmission.

61. Pulse oximetry devices, used to measure SpO2, are designed to operate at the macroscale or sensor scale (emitter and detector scale) and are generally described as operating in two modes: transmission mode and reflection

mode. Transmission Mode: In this mode, the light emitter and the detector are generally positioned on opposite sides of the tissue. Light from the emitter penetrates the tissue and takes a general path that passes through the tissue to the opposite side of the tissue, and the detector measures the light that has traversed the tissue. Reflection Mode: In this mode, both the light emitter and the detector are generally positioned on the same side of the tissue. Light from the emitter penetrates the tissue and takes a general path that passes through the tissue and back to the same side of the tissue, and the detector measures the light that has traversed the tissue.

62. From the perspective of light transmission through the tissue bed, there is no difference between these two modes. Once a photon has traveled a sufficient distance to lose its history (less than 1 mm in tissue for pulse oximetry wavelengths), it becomes irrelevant whether the detector is positioned opposite the emitter or on the same side. This is because, after traveling this distance, the photon's interactions with the tissue have caused it to diffuse in such a way that its path is randomized, and light is absorbed along whatever path the light takes.

63. Reflectance and transmission are best considered as practical design and manufacturing terms. They describe the physical arrangement of the emitters and detectors rather than any fundamental difference in the measurement process. Both geometries are used to measure the diffused absorption of light through a

blood-perfused tissue bed, providing essential information about blood oxygen saturation levels.

64. Whether in transmission or reflection mode, pulse oximeters measure the same optical phenomena: the interaction of light with the blood and tissues. This interaction is key to determining oxygen saturation, as it relies on the differential absorption characteristics of oxygenated and deoxygenated hemoglobin

6. Multiple LEDs have been commonly used for biometric monitoring

65. Using multiple LEDs is beneficial to offset noise effects of ambient light and sunlight in real-time vital sign monitoring devices. For example, U.S. Patent No. 7,468,036 to Rulkov et al. ("Rulkov") recommends a "greenlight LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight." Ex-1039, 6:56-58. Rulkov also uses multiple LEDs of green and infrared wavelengths, with a preferred embodiment in which the optical sensor includes "a plurality of light emitting diodes" ("LED") based on green light, and further describes monitoring vital signs in which "the plurality of light emitting diodes comprises a plurality of pulsed infrared light emitting diodes." *Id*., 6:49-58. A POSITA would have understood that multiple emitters each including multiple LEDs operating at different wavelengths advantageously provide "accurate" "real-time information to the user about the user's health" by, for example, enabling

offset of noise affects. *Id*., 4:4-8.

66. U.S. Patent Publication No. 2006/0211924 to Dalke et al. ("Dalke") also discloses the use of multiple spaced-apart LEDs operating at various wavelengths and/or intensities. Ex-1040. Dalke states "there can be any number of LED groups and any number of LEDs within a group" and further that such LEDs "may be grouped according to output intensity or wavelength or both." Ex-1040 ¶ 75.

7. Separation distance between LEDs and the photodiode is a design consideration for the quality of the acquired data

67. From a system design and performance perspective, determining the ideal separation distance between the LEDs and photodiode is important. To enhance the quality of the plethysmogram signal one method includes placing the photodiode close to the LEDs. Ex-1041 (Guidelines to enhancing), 0005. However, if the photodiode is too close to the LEDs, the photodiode becomes saturated by measurements that do not relate to the heart signal of the user. *Id*. To have a constant LED intensity, "the total light detected by the photodiode decreases roughly exponentially as the radial distance between the LEDs and the photodiode is increased." *Id*. Thus, placing the photodiode farther apart from the LEDs can result in a plethysmogram with a larger signal that relates to the heart signals of the user. *Id*. As an example, U.S. Patent No. 4,880,304 to Jaeb et al.

("Jaeb") uses this method and resolves the problem of low signal strength by placing its LEDs 16 and 18 in a radial pattern around detector 20 that detects the light of the LEDs. Ex-1042, 5:6-8.

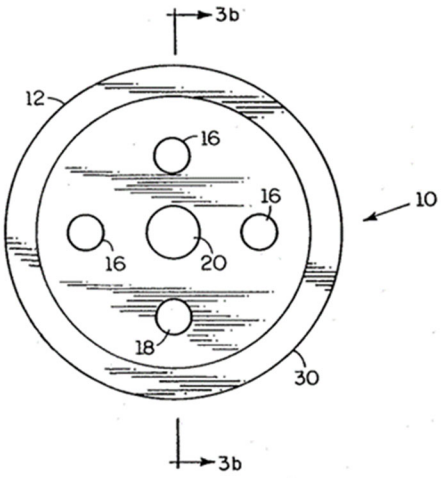


FIG. 3a

B. Wearable Electronic Device Arrangements

68. In view of the various applications that wearable electronic devices can be used, there are various considerations that a POSITA must consider when designing a wearable electronic device. I have summarized only a few considerations of the electronic device arrangements below.

1. Wearable devices having inner and outer surfaces were Known

69. Finger-ring structures having inner and outer surfaces with electronics housed inside within a cavity were known. For example, Rhee's thesis and papers

teach a finger-ring sensor having inner and outer surfaces. Specifically, Rhee teaches, as shown in Figure 1 (Rhee 2000 Part II) and Figure 3 (Rhee 2001) below, that an "inner ring floats inside the outer ring" such that "[w]hen a patient wears the ring, both rings are put on the same finger." And, "[s]ince the outer ring covers the inner ring, the external force is born by the outer ring and does not directly act on the inner ring." Ex-1032, 2796 (Rhee 2000 Part II); Ex-1033, 799 (Rhee 2001); Ex-1035, 68 (Rhee Thesis 2000) (same).

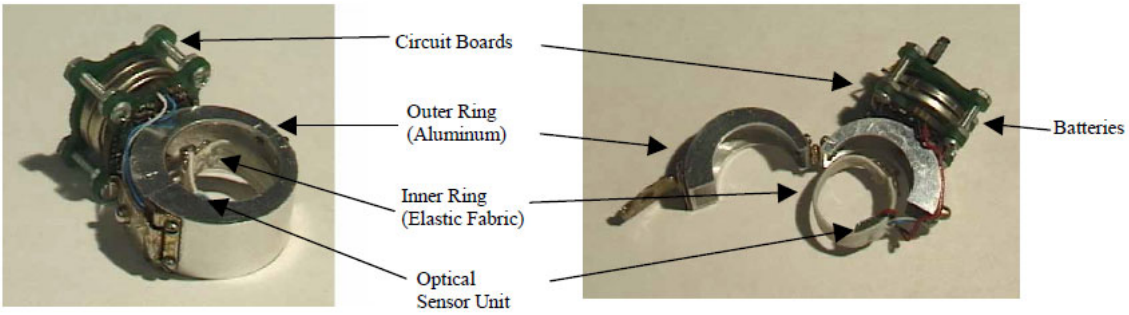


Figure 1 : Isolating ring sensor designed for motion artifact minimization

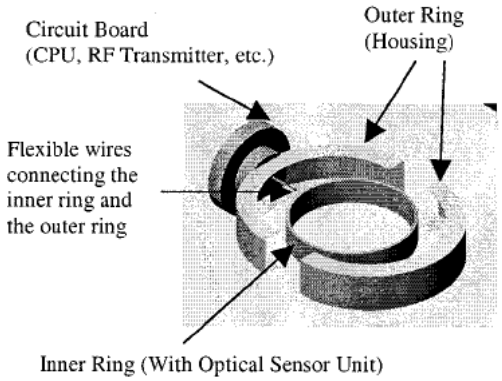


Fig. 3. Construction of isolating ring.

2. Various ways to assemble electronic parts within structural cavities were known

70. The formation of cavities, whether by single-structure formation or

multi-structure assembly techniques, is essential for integrating electronic components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This is crucial in the manufacturing of electromechanical devices ranging from cars and computer interface devices to phones, toys, watches, electronic medical devices, and other modern battery or wall-power operated devices. Manufacturing and assembly approaches vary based on tooling sizes, costs, and complexities.

71. Most objects seen in everyday life are non-planar. Therefore, it is necessary that the electronic systems fit a convenient form factor of the shape into which it will be integrated.

72. Creating a mechanical part from raw material involves bulk material removal, forming cavities or holes, and finishing to meet specifications. Techniques like milling, drilling, and EDM are commonly used. For difficult-to-machine materials, processes such as electro-discharge machining, laser beam machining, electron beam machining, shaped tube electrochemical machining, and electrochemical spark machining are employed. To meet stringent micro- to nanometer range requirements, advanced finishing techniques like abrasive flow machining, magnetic abrasive finishing, magnetic float polishing, magneto-rheological abrasive finishing, and ion beam machining have been developed.

73. For the integration of electrical circuits into products, the use of

electronics flexible systems as inserts to replace traditional rigid substrates in injection molding machines has become common.

74. Common Techniques include:

a. Machining for Metals: Milling, drilling, EDM, and additive manufacturing.

b. Formation for Plastics: Molding and thermoforming.

c. Chip and PCB Packaging Techniques: Incorporating methods from semiconductor and PCB manufacturing.

75. There are many examples in the art of ways that electronics could have been assembled within a wearable electronic device by 2013. For example, U.S. Patent No. 4,830,014 to Goodman teaches that the light source and the photosensor may be mounted to substrates using "sequential layers of surgical tape, opaque vinyl, and light filters" and "constructed of such small dimensions that both independently conform with a low aspect ratio to the flexible adhesive strip." Ex-1024, 6:10-21 (Goodman).

76. Further, by 2013 it was well understood that in order to house electronic components within wearable devices, there must be an internal space like a cavity within the mechanical or structural elements. From a manufacturing and assembly perspective, a cavity can either be premade, with electronic components subsequently assembled and attached into it, or the electronic

components themselves can be used to define the cavity during a molding process. Either approach ensures efficient integration of electronics into wearable devices, accommodating their compact and functional design requirements. For example, U.S. Patent Application Publication No. 2012/0218184 to Wissmar (Ex-1013), teaches electronic components "located in a cavity within the electronic finger ring." Ex-1013 ¶28. Wissmar's finger ring is a toroidal shaped finger ring structure made with, "two different metallic shells: (i). 1 a, made of gold (Au) or silver (Ag), enclosing the major parts of the finger ring structure geometrically described as radially furthest away from the toroids centre, and (ii). 1 b, made of a titanium compound (Ti, TiW), being the metal enclosing facing the inner parts of the finger ring structure." *Id*. ¶73. As shown below in Figure 1, the "toroidal shaped finger ring structure 1 is comprised of different electronic components: a battery 2, a RF transceiver 3 and a micro processor 4, a microstrip line 5, an accelerometer 6, an internal antenna 7, a pressure sensor 8; all mounted on a flexible printed circuit board 9. In this embodiment, there is also an outer metal shell opening 10 serving as an RF window letting through unperturbed RF radiation." *Id*. ¶73. The components shown in Figure 1 are housed within the cavity in the electronic finger ring.

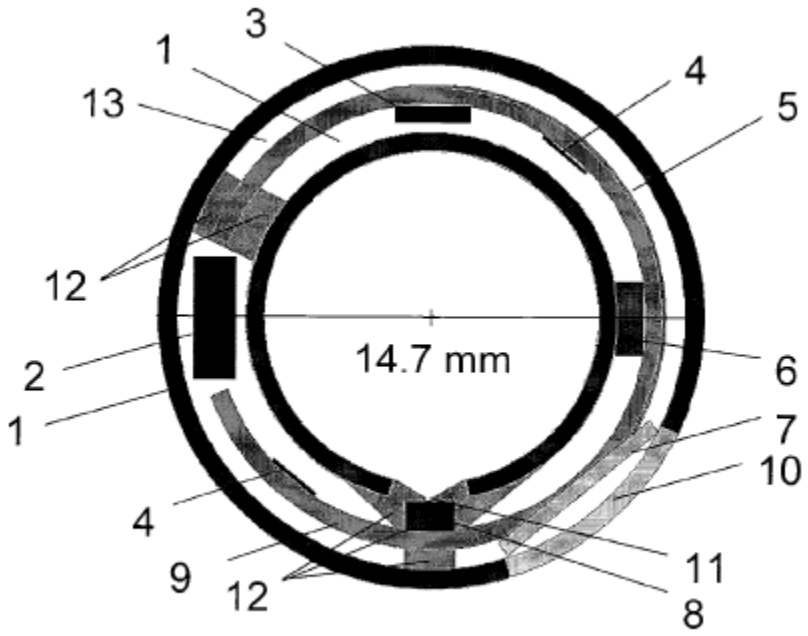


Fig. 1

77. Similarly, U.S. Patent No. 6,201,698 to Hunter teaches that "the side walls and the web together create a cavity [] to house the electronic circuit." Ex-1060, 2:56-57.

78. U.S. Patent No. 4,012,629 to Simms also teaches a flashlight ring that includes "a hollow toroidal finger encircling member formed in four sectors" with each sector having its own electronic components inside. Ex-1061, Abstract.

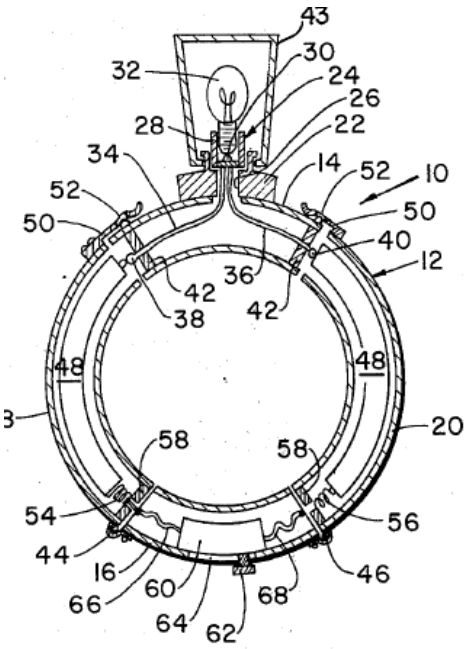
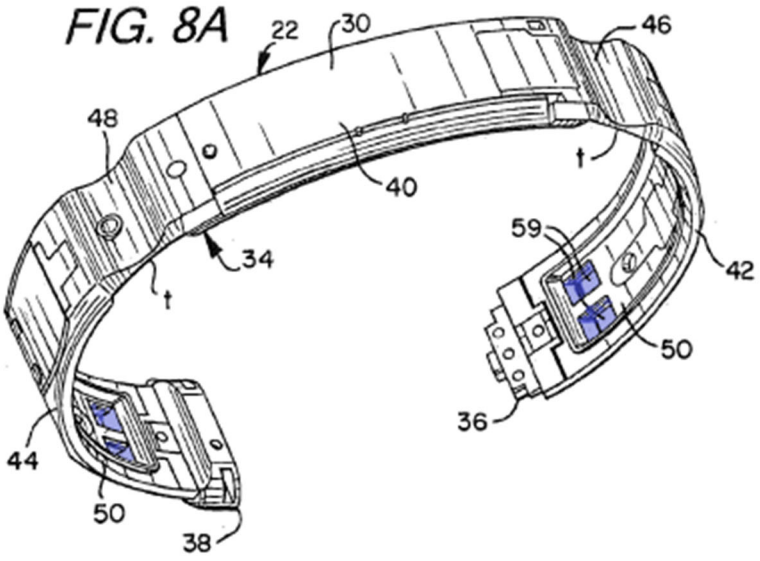


FIG. 2

79. Moreover, Moreover, U.S. Patent Publication No. 20140244009 to Mestas teaches an electronic wearable device that has "compartments" for its electronic components. Mesta's device has "compartments for power supplies, an outer encasement member 24, and a fastening mechanism 26 or latch member 26." Ex-1010 ¶151; *see also id*. ¶183 ("light member compartment 180"). Further, Mestas explains that the batteries are inserted into the battery compartments. *Id*. ¶157. For example, as shown in Figure 8A, the "recessed compartments 50,52 are dimensioned to receive power supplies associated with the controller 14 . compartments 50,52 further have a pair of openings 59 to receive battery terminals or contacts to be described. The recessed compartments 50,52 may vary in size

generally or with respect to one another. Thus, the recessed compartments 50,52 may have an increased size to accommodate larger power supplies having increased capacity." *Id*. ¶156. "The batteries are positioned in the recessed compartments 50,52 wherein the contacts 150 extend through the openings 59 in the compartments 50,52 and engage the PCB member 140 to provide power to the device 10." *Id*. ¶168. Therefore, it was well known to have compartments, or voids, inside a wearable electronic device in order to house specific electronic components.



80. Encapsulating electronics within a cavity of a structural element by, for example, injection molding, was well known by 2013. *See, e.g.*, Ex-1055, Ex-1056, Ex-1057, Ex-1058, and Ex-1059. I discuss this in more detail below in Section VIII.C.

81. Housing electronic parts within one component or between two components was known. For example, U.S. Patent No. 6,699,199 to Asada teaches that "one or more photo diodes 2 and one or more light-emitting diodes (LEDs) 4 are imbedded in a ring 10." Ex-1034, 2:59-61 (Asada '199). Moreover, U.S. Patent No. 6,745,061 to Hicks teaches that "[i]ncluded within the assembly 350 are upper and lower flexible members 304 and 300, respectively," which are "thermally bound to one another sandwiching a leadframe 308 between their inside surfaces." Ex-1025, 6:48-54 (Hicks). "This leadframe 308 contains active components (i.e., LEDs and a photodetector) for use in oximetry measurements." Ex-1025, 6:48-54 (Hicks).

82. Electronic parts housed within a structural cavity in an electronic device could include, for example, microcontrollers, batteries, and RF communication components. For example, Rhee's thesis and papers teach a ring sensor that included "optoelectronic components, a CPU, a RF transmitter, a battery, and a ring chassis," wherein the "optoelectronic components, i.e. microphotodiodes and LEDs, detect the blood volume waveforms and oxygen saturation level at the patient's digital artery. The CPU controls the LED lighting sequence as well as the data acquisition and transmission process. These signals are locally processed by the on-board CPU and transmitted to a host computer for diagnosis of the patient's cardiovascular conditions." Ex-1031, 1 (Rhee 2000 Part

I); Ex-1032, 2796 (Rhee 2000 Part II) ("The basic circuit configuration of the ring sensor is a standard photoplethysmographic circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. … The two channels of digital signals are transmitted via a RF transmitter. … "[T]he whole system is designed and operated for low-power consumption. … Each component has to be selected for low-power consumption and the whole system must be operated for minimum power consumption. The microprocessor coordinates the whole operation so that reliable measurement is performed with minimum power. The main circuit board and batteries, which are heavy and bulky in comparison to the sensor unit, sit on the outer ring."); Ex-1033, 796-97, 799, Fig. 1 (Rhee 2001) (same); Ex-1035, 14, 21-22, 68 (Rhee Thesis 2000) (same).

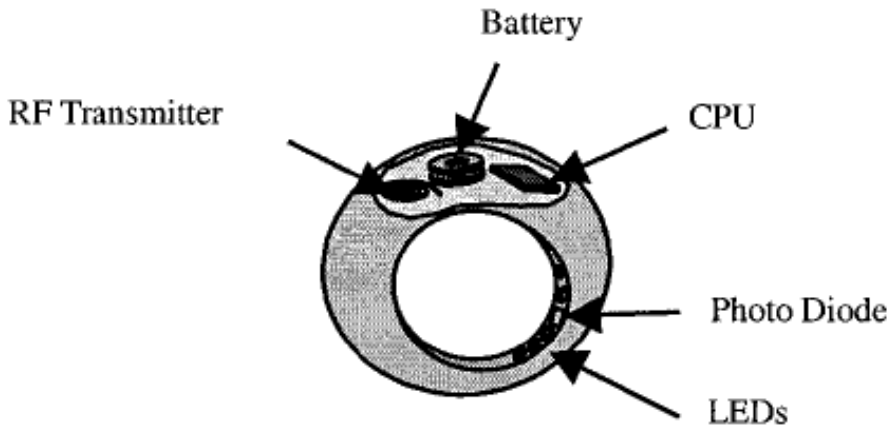


Fig. 1. Conceptual diagram of the ring sensor.

83. Moreover, Harry Asada and his MIT team by 2003 developed a finger-ring prototype having an "optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered by a tiny cell battery used for wristwatches"; and a PIC microcomputer for performing device controls and signal processing including "LED modulation, data acquisition, filtering, and bi-directional RF communication." Ex-1037, 34 (Asada 2003); *see also* Ex-1034, 3:12-21 (Asada '199) ("Referring now to FIG. 2, a cross-section is shown of finger ring sensor 20 as worn on finger 22 of a patient. In preferred embodiments of the invention, a sensor band 21 is worn in direct contact with the finger and holds one or more Detector S2 and 26, against the skin of the finger. sensor band 21 is encompassed by base ring 23 which, in turn, is encompassed by cover ring 25 which supports circuit mod ule 29 containing battery 12, processor 6, and transmitter 8, all shown in FIG. 1, and serves also to shield detectors 2 and 26 from ambient light.").

84. It was also known by 2013 that electronics in a wearable electronic device could be assembled at the bottom of the device (i.e., away from the skin surface). For example, the Konig reference teaches that, in transmission pulse oximetry "[t]he optical elements are located on the opposite sides of a body part" and "[t]he sensors are applied mainly to the fingers and toes." Ex-1027, 405 (Konig).

3. Attaching electronics to a surface within an electronic device was known

85. A POSITA would have understood by 2013 that electronics should be attached to a surface in the device and that where that attachment occurs (for example, at the top or bottom of a cavity) would have been a matter of design and manufacturing choices. As an example, Harry Asada and his group at MIT state that "transmittal PPG configurations do not have the short circuit problems" of reflective PPGs because "the LED and PD are placed on the opposite sides of the finger" (i.e., at the bottom surface) such that "no direct path through the air can be created." Ex-1037, 31 (Asada 2003). This type of design allows the use of "devices having a weak polarity, which is, in general, more robust against disturbances." Ex-1037, 31 (Asada 2003). Moreover, transmittal PPGs are also "less sensitive to local disturbances acting on the finger, since the LED irradiates a larger volume of the finger." Ex-1037, 31 (Asada 2003). Importantly, Asada notes that "[d]esign trade-offs must be considered to find the best modulation scheme." Ex-1037, 32 (Asada 2003).

86. Rhee's thesis and papers teach, as shown in Figure 2 below, that in an original design (a) the "optoelectronic sensor unit, i.e. the LEDs and photodiodes, is attached directly to the body of the ring." Ex-1031, 2 (Rhee 2000 Part I); Ex-1033, 796 (Rhee 2001); Ex-1035, 17 (Rhee Thesis 2000). Rhee notes that the

problems with that design were fluctuations in the sensor reading, displacement of the ring relative to the skin surface, and difficulty shielding the sensor unit from ambient lighting. Ex-1031, 2 (Rhee 2000 Part I); Ex-1033, 797 (Rhee 2001). "To resolve these problems of the original ring design, a new design" was developed, called an "isolating ring configuration" (b), which "separate[s] the sensor unit from the rest of the ring body that is much heavier than the optical sensor unit alone." Ex-1031, 2 (Rhee 2000 Part I); Ex-1033, 797 (Rhee 2001); Ex-1035, 17 (Rhee Thesis 2000). "The separation is achieved by having two rings that are mechanically decoupled to each other," wherein "[t]he inner ring holds sensor unit alone, while the outer ring contains the CPU, signal processing unit, battery, and RF transmitter" and "[o]nly a thin, flexible cable connects the two rings." Ex-1031, 2 (Rhee 2000 Part I); Ex-1033, 797 (Rhee 2001). Rhee teaches that the advantages of this design are that it alleviates the influence of external forces applied to the ring (because the outer ring bears the force not the sensor unit on the inner ring), it alleviates the effect of acceleration on the sensor, reduces skin pressure, and reduces ambient lighting influence. Ex-1031, 2 (Rhee 2000 Part I); Ex-1033, 797 (Rhee 2001). Rhee additionally teaches that "[a] miniaturized sensor unit is attached to the inner ring whose mass is almost negligible," which is "a small circuit board … contain[ing] two light emitting diodes and a photodetector." Ex-1032, 2796 (Rhee 2000 Part II); Ex-1033, 799 (Rhee 2001); Ex-1035, 68 (Rhee

Thesis 2000).

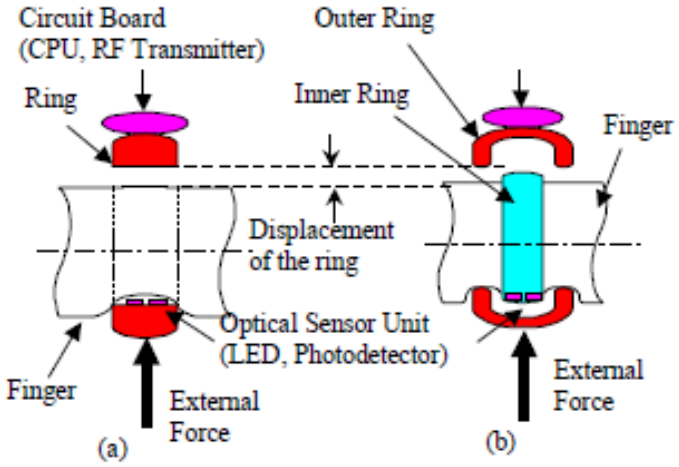


Figure 2 : Dislocation of ring sensors due to external load
(a) Traditional single body design under external force
(b) New isolating ring sensor under external force

87. There are also examples in the prior art where electronics were attached to the bottom surface. For example, U.S. Patent No. 6,608,562 to Kimura states that "[t]he photo diode 23 is disposed at the bottom of the inside of the attachable device 1 where it can receive the returning light." Ex-1028, 6:60-62 (Kimura). U.S. Patent No. 6,745,061 to Hicks also states that "[m]ounted on a top surface of the clear flexible substrate is at least one active pulse oximetry component," which includes "at least one light emitter, such as a light emitting diode, and/or a light detector, such as a photodiode." Ex-1025, 2:12-18 (Hicks). "Particularly, these active components are mounted on the top surface of the clear substrate such that they emit/detect light through the clear substrate and its bottom surface." Ex-1025, 2:12-18 (Hicks); *see also* Ex-1025, 2:31-32 (Hicks) (noting

that "the bottom surface of the clear flexible substrate" is "the patient side of the sensor," which means that the "top surface of the clear substrate" would be the side that is away from the patient's skin, 10:15-17 ("The traces 70-76 of the present embodiment are formed on the top surface of the clear substrate 80 using a conductive ink (e.g., epoxy with silver).").

4. Flexible and rigid-flex printed circuit boards were well-known

88. Wearable electronic devices and sensors often present space, weight, and geometry constraints in the design, manufacturing, and placement of their electronic components. To address such constraints, the electronics can be placed on flexible printed circuit boards ("PCBs"), which were well-known by 2013.

89. Flexible PCBs are made from materials such as Kapton, which are used due to their thermal stability, mechanical flexibility, and electrical insulation properties. These properties enable them to conform to various shapes and endure bending and flexing during manufacturing assembly and use while maintaining its digital or analog circuit functionality. Their flexibility is essential in applications requiring the PCB to adapt to non-flat surfaces without compromising the electronic performance. For example, Petropoulos describes the fabrication of a flexible PCB made of Kapton foil, which exhibits lower thermal conductivity (thus better thermal insulation) and is much thinner than a regular, rigid PCB. Ex-1052,

237 (Petropoulos).

90. By 2013, flexible PCBs and arrangements of flexible and rigid PCB ("rigid-flex" PCBs) were widely utilized in wearable electronic devices. For example, U.S. Patent No. 8,954,135 to Yuen teaches a wearable biosensing device where its light source(s) and/or associated detector(s) are disposed on a Flat Flex Cable or "FFC" or flexible PCB. In this embodiment, the flexible or pliable substrate (for example, FFC or flexible PCB) could connect to a second substrate (for example, PCB) within the device having other components disposed thereon (for example, the data processing circuitry)." Ex-1006, 12:35-42 (Yuen). This flexible structure allows the inner, "skin-side" surface of the device to conform or adapt to the shape of the user's body (for example, arm, wrist, ankle or leg) that the device is secured to so that there is "little to no gap between the skin side of the device and the juxtaposed surface of the skin of the user." Ex-1006, 12:24-42 (Yuen). Similarly, U.S. Patent No. 10,303,867 to Schröder teaches a flexible PCB, but teaching that electronics such as antenna coil and a chip module in its biosensing "finger-ring" are applied on a "carrier foil" that "consists of a flexible plastic material, e.g. PET or Kapton," through technologies such as a printing technique. Ex-1007, 12:27-37, 13:23-37 (Schröder). U.S. Patent Pub. No. 2014/0244009 to Mestas also teaches the use of flexible and rigid-flex PCBs in its wearable electronic biosensing device, where the electronics are disposed on a

spine member "having substantially rigid portions and certain flexible portions or zones." Ex-1010, ¶¶151, 153 (Mestas). Mestas further teaches that a rigid-flex printed circuit board (PCB) is wrapped onto the spine of the device and similarly includes rigid zones (annotated dark purple below) connected by flexible zones (light purple) for placing the various electronic components. *Id.*, Figs. 14, 15, ¶¶164, 177 (Mestas). The decision to utilize a rigid, flexible, or rigid-flex PCB is driven and balanced by an evaluation of the trade-offs between costs and benefits and system-design decision for an entire device.

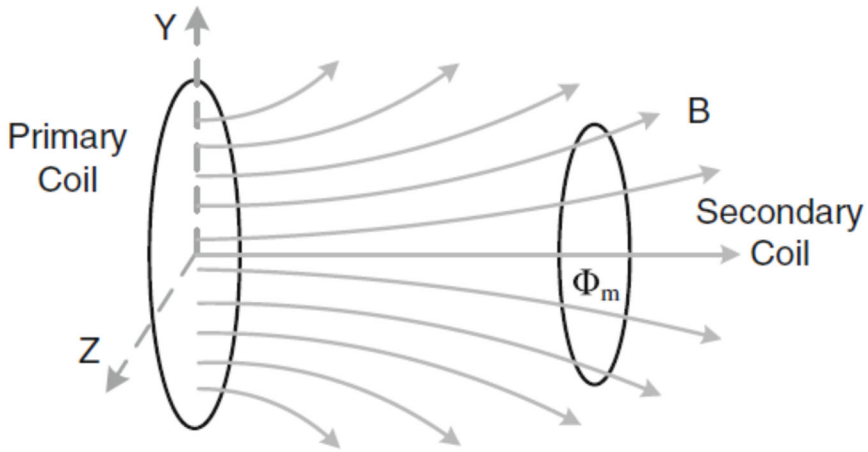
5. Wireless inductive charging was well-known

91. The benefits of wireless charging batteries powering electronic devices, in particular wearable electronic devices, were well known by 2013.

92. As noted in Sun's Wireless Power Transfer for Medical Microsystems book from 2013, "wireless power transfer (WPT) . . . was invented over 100 years ago." Ex-1053, 1 (Sun). By 2013 wireless power transfer was used either for "real-time energy" or "to charge batteries" in biomedical devices. *Id.*, 140 (Sun). Near-field (as opposed to long-distance) wireless power transfer can be one of two types: inductive coupling or capacitive coupling. *Id.*, 5, Fig. 1.4 (Sun). While capacitive coupling relies on capacitors, inductive coupling, which Sun notes is the "best choice for biomedical app[lications]," relies on coils. *Id.*, Fig. 1.6 (Sun). As Sun further explains, "[t]he most well-known power antenna for biomedical

applications is the magnetic inductive coil." *Id.*, 42 (Sun).

93. Inductive coupling relies on magnetic flux coupling between a coil of a primary power transmitter and a coil of a secondary power receiver, which are not physically connected. *Id.*, 19 (Sun). The coil and its connected electronics on the receiving side picks up the time-varying magnetic field created by the coil on the transmitting side, thus transferring electromagnetic power wirelessly. *Id.*, 19, Fig. 2.2 (reproduced below).



94. Besides its use in biomedical devices, induction charging was also widely used by 2013 for charging batteries of wearable electronic devices and many type of cordless consumer devices. For example, U.S. Patent Pub. No. 2014/0187160 to Prencipe teaches a wireless communication enabled smart ring with a "battery [that] is rechargeable by any suitable recharging method, including but not limited to induction (e.g., from a charging station or from ambient electromagnetic radiation). Ex-1054 ¶36 (Prencipe). Similarly, Mestas teaches a

wearable athletic device that "may be configured for re-charging batteries via induction charging." Ex-1010 ¶201 (Mestas). Similarly, Schröder teaches a biometric sensing "finger-ring" with a battery that "is preferably charged by means of [an] electromagnetic field," using an antenna coil. Ex-1007, 11:46-67 (Schröder).

C. Wearable Electronic Device Materials

1. Machinability of metallic materials was known

95. Materials such as metals including titanium were known to be machinable by 2013. For example, Olofson's Machining of Titanium Alloys book from 1965 states that "[t]oday, tools and techniques are available for machining titanium efficiently." Ex-1036, 1 (Olofson). "In fact, some machining operations give more consistent results on titanium than they do on some grades of steel." Ex-1036, 1 (Olofson). "A bonus factor is the ease of attaining good surface finishes." Ex-1036, 1 (Olofson). "Rms [room mean square] values as low as 20 to 30 microinches can be obtained on some titanium parts without much trouble." Ex-1036, 1 (Olofson). Olofson's Table 1 "shows the approximate machinability relationships between the titanium alloys and the other alloys of interest." Ex-1036, 1 (Olofson) (comparing aluminum alloys, alloy steel, stainless steel, and titanium alloys among others).

2. Using a moldable filler material or potting material to cover electronics was known

96. Using a moldable filler material or "potting material" to cover the electronics in a device was known by 2013 including the motivations for doing so. Similar materials are suitable for both molding and potting processes in manufacturing. Both molding and potting processes require materials with attributes such as thermal stability, electrical insulation, and mechanical strength.

97. By 2013, injection molding was "the most popular method for producing plastic products because of its high productivity and the manufacturability for making various complex shapes." Ex-1056, 51 (Ciofu). The "[i]njection process is a cyclical process, during which succession occurs following operations: dosing of plastic material; heating and melting the plastic inside the cylinder; closing the mold; placing plastic material inside the mold cavity under pressure; melt solidification and cooling; mold opening; elimination product injected." Ex-1056, 52 (Ciofu). Moreover, "[q]uality parameters (responses) are usually associated with evaluating the replication fidelity of the processes by completely filling the mould cavity." Ex-1056, 55 (Ciofu), 57-57 ("feature engineering that refers to filling cavities is influenced by the part geometry, size and position of point size and shape filling and filling channels"); *see also, e.g.*, Ex-1058, 61 (Sakai) ("Plastic packaging for semiconductor products such as

integrated circuits (ICs) has been commercially made by means of a transfer molding method using epoxy resin."), 65 (applying "a quantitative analysis for molten polymer filling behavior in the cavities using a mold-filling simulation program commercially available such as Mold Flow"), 66 ("Figure 11 shows the experimental results using the 16-cavity side gate cold-runner system"), Fig. 11; Ex-1059, 10 (Teh) ("Figure 1 illustrates an example of such injection moulded thermoplastic parts with an embedded electronic subassembly. This proposed encapsulation technology adapts conventional techniques of thermoplastic injection moulding and electronic printed wiring board (PWB) assembly in order to achieve economical efficiency and manufacturing viability."), 11 ("As shown in Figure 2, injection moulding can be briefly described as a cyclic process of forming plastic into a pre-determined geometry by forcing high-temperature plasticized or molten polymer resin under an injection pressure into a specially shaped cavity (mould)."), Figs. 1-2.

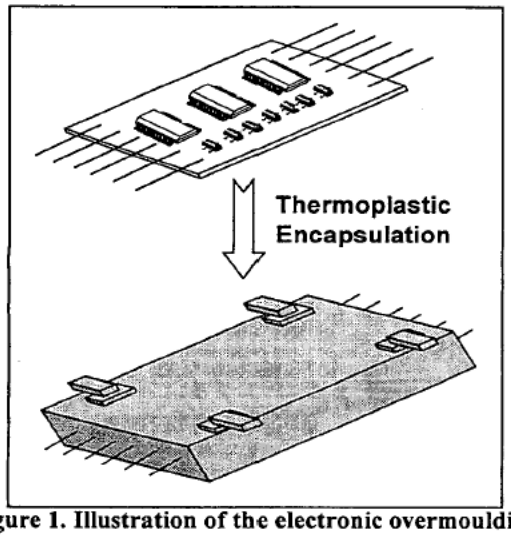


Figure 1. Illustration of the electronic overmoulding

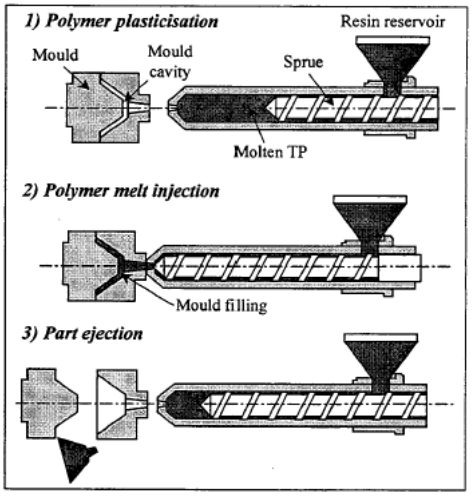


Figure 2. Schematic diagram of injection moulding

98. As Ardebili's Encapsulation Technologies for Electronic Applications book from 2009 explains, "[p]otting involved positioning the electrical circuit in a container and pouring the liquid encapsulant into the cavity." Ex-1055, 3 (Ardebili). "Common materials used for potting . . . of electronic units are silicones, epoxies, and polyurethanes." *Id.*, 90. A related encapsulation technique, "molding is a process of encapsulating microelectronic devices in a closed mold." *Id.*, 129 (Ardebili). Molding compounds include similar materials: "resins, . . ., silicones, phenolics, and BPA epoxies." *Id.*, 57 (Ardebili).

99. Ardebili also discusses encapsulating electronics within a cavity. *See, e.g.*, Ex-1055, 4 (Ardebili) ("The encapsulant, typically a thermosetting polymer, is cured in the cavity to form the final electronic package."), 6 ("Plastic packages can be pre-molded or post-molded. In the pre-molding process, a package base is prepared from a pre-molded plastic (or sometimes a metal substrate). The chip is

then placed on the base and connected to an I/O fan out pattern with wire. A pre-molded plastic lid or housing is attached on top, using an epoxy adhesive to protect the die and wire bonds, and forms a cavity inside the package. Figure 1.5 shows a pre-molded package. Pre-molded packages are most often used for high-pin-count devices or pin-grid arrays that are not amenable to flat lead-frames and simple fan out patterns."), 31 ("Hermetic packages are cavity packages that are designed to seal against moisture and corrosive gases. They are made of materials that are highly moisture impermeable such as ceramics and metals. A metal or ceramic lid (or housing) is welded or attached to a package base to produce the hermetic seal."), 437 ("Figure 8.12(a) shows another example of selective encapsulation of a MEMS suspension sensor chip that includes a cavity constructed on the back surface. Figure 8.12(b) shows selective plastic encapsulation of a MEMS [micro-electromechanical system] device stacked on an IC chip. Figure 8.13 shows a selective encapsulation method for a MEMS pressure sensor from Motorola [22]. A protective dam is constructed on the outer perimeter of the pressure sensor diaphragm, thus forming a cavity between the dam and the package housing. The cavity can be filled with plastic encapsulant material. The package housing is also made of plastic material.").

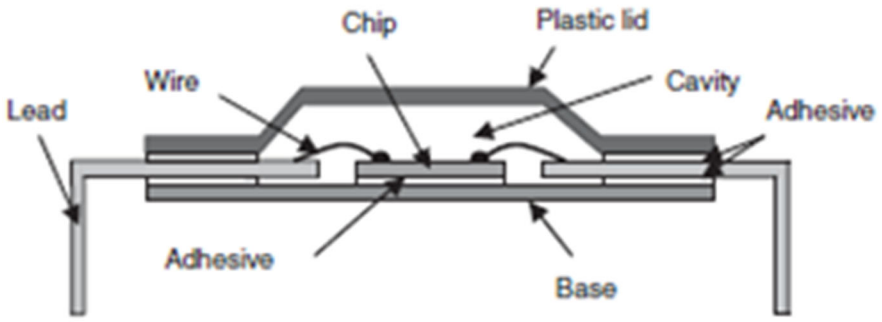


Figure 1.5 A pre-molded plastic package [9].

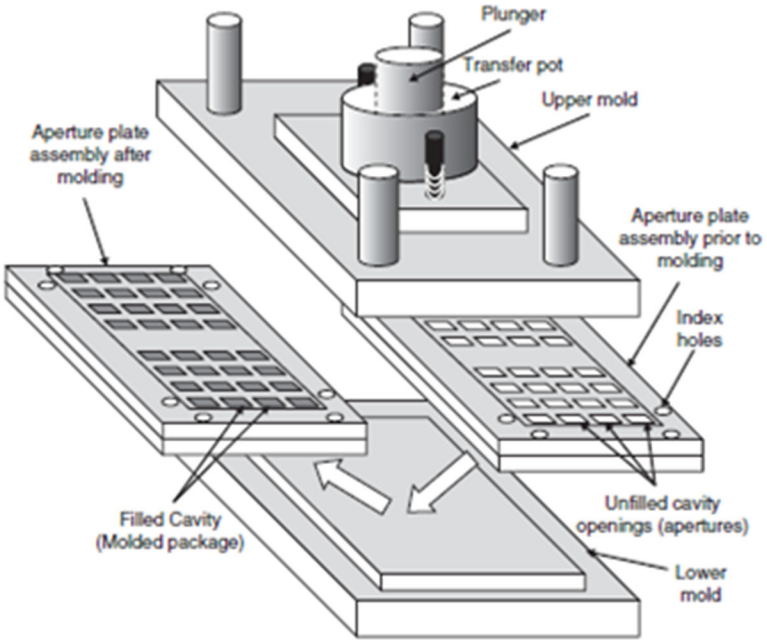


Figure 3.4 Aperture-plate (or cavity plate) molding setup [3].

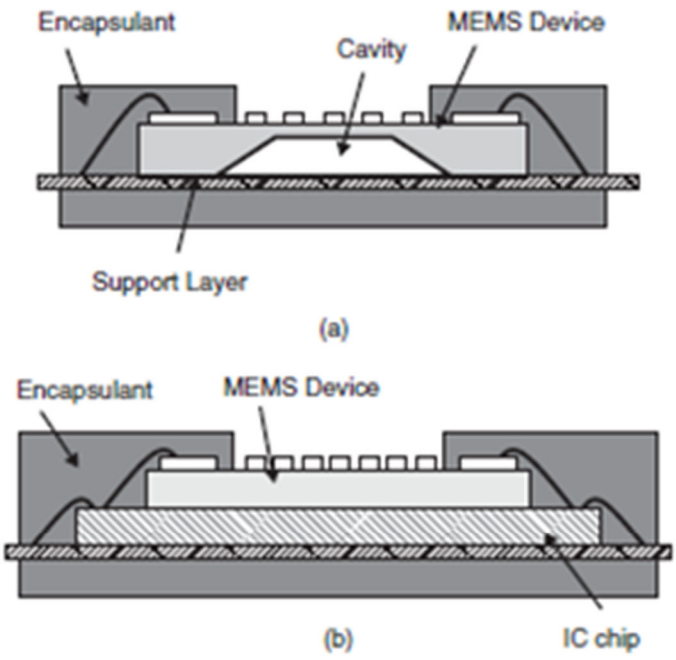


Figure 8.12 Plastic-encapsulated MEMS device package designs from Industrial Technology Research Institute: (a) MEMS device with a cavity; (b) 3D package with a MEMS device stacked on an IC chip [21].

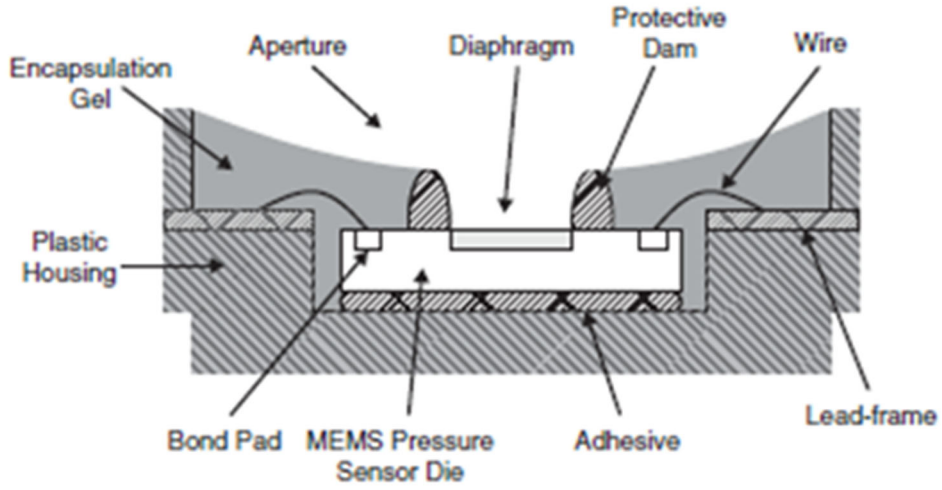


Figure 8.13 Plastic-encapsulated MEMS pressure sensor device from Motorola [22].

100. As applications of these encapsulation or coating techniques, for example, it was known that a light source and photosensor may be mounted to

substrates using "sequential layers of surgical tape, opaque vinyl, and light filters." Ex-1024, 6:10-21 (Goodman). "Thereafter, apertured, opaque vinyl and finally a transparent adhesive layer are placed over the entire photo-sensor" resulting in "a simple flexible adhesive strip apparatus which is in conformance to the blood perfused flesh, i.e., digit being interrogated for blood flow." Ex-1024, 6:10-21 (Goodman); *see also* Ex-1057, 1809 (Ross) ("If the package body material is not tightly adhered to the penetrating leads on all four sides there will be a direct and open moisture path to the package interior and a gas leak path to the exterior of a sealed package during gross leak testing.").

101. The advantages of using moldable filler or potting materials to cover electronic parts include "that the blood flow of a critically compromised patient may be measured with limited risk of measurement error incurred by motion artifact; the foam layer between the adhesive and the substrate provides a tight, nonpressure exerting, skin seal which prevents motion artifact"; "the foam layer between the adhesive and the substrate provides a light-tight seal between the skin and the sensor, thus protecting the components and resulting measurement from the deleterious effects of ambient light"; and "an opaque photographic coating applied to the foam/adhesive side of the flexible substrate prevents measurement inaccuracies by diminishing light refraction and rebound." Ex-1024, 7:32-49 (Goodman); *see also* Ex-1059, 11 (Teh) (discussing "the technological and

economic implications of … overmoulding technology … in the production of highly integrated polymer encapsulated electronics products"), 12 (the advantages of encapsulating electronics within structural moulding is "Reduced package size," "Lower manufacturing costs," "Better product durability," "Improved system robustness," and "Product recyclability").

102. U.S. Patent No. 6,745,061 to Hicks ("Hicks, Ex-1025) teaches that the coating could be an epoxy or an ink. For example, Hicks states that "the flexible sensor may contain a light blocking layer applied to the top surface of the clear flexible substrate to minimize the effect of ambient light sources upon the sensor," which "may include a separate substrate interconnected to the clear flexible substrate or some sort of opaque coating applied to the top surface of the clear flexible substrate." Ex-1025, 2:42-48 (Hicks). Hicks further teaches that "traces 70-76 of the present embodiment are formed on the top surface of the clear substrate 80 using a conductive ink (e.g., epoxy with silver)." Ex-1025, 10:15-17 (Hicks). Moreover, Hicks teaches that "[d]uring the ink deposition process, the remainder of the surface of the clear substrate 80 not covered by the conductive traces 70-76 (and not to be covered by the LED 40, 42 or Photodetector 38) may also be covered by an opaque nonconductive ink." Ex-1025, 10:20-27 (Hicks). "That is, the non-patient side of the clear substrate 80 may be 'painted' to provide a light blocking shield for the sensor 30." Ex-1025, 10:20-27 (Hicks); *see also* Ex-

1025, 9:6-15 (Hicks) ("The release liner 84, the interconnecting layer 82, the foam layer 86 and the clear substrate layer 80 are formed of materials that are substantially transparent to ultraviolet (UV) light. This allows UV light to pass through these layers 80-86 such that any adhesives used to attach the LEDs 40, 42 and photodetector 38 to the electrical traces 70-76 and/or to the clear substrate 80 (i.e., adhesive drop 110) may be cured with light (i.e., UV or visible depending on the adhesives) applied through the bottom of the flexible substrate 50 at or near the end of the manufacturing process."), 12:2-13 ("[T]his embodiment further uses a cover layer 94 covering the top surface of the clear substrate. … The cover layer 94 covers substantially the entire top surface of the clear substrate 80, excluding the portion of the clear substrate that makes up the integral connector 94. This cover film layer 94 is generally an opaque flexile layer made up of a material similar to the clear substrate 80 and is utilized for its light blocking characteristics.").

103. U.S. Patent No. 8,954,135 to Yuen (Ex-1006) is another example of a moldable filler material or "potting material" used to seal the electronic components inside a wearable device. For example, Yuen describes that its biometric monitoring device "may be filled with gel that allows the sensor to experience pressure changes outside of the gel. The use of a gel filled altimeter may give the device a higher level of environmental protection with or without the

use of an environmentally sealed vent. The device may have a higher survivability rate with a gel filled altimeter in locations including but not limited to those that have high humidity, a clothes washer, a dish washer, a clothes dryer, a steam room, the shower, a pool, and any location where the device may be exposed to moisture, exposed to liquid or submerged in liquid." Ex-1006, 20:65-21:8.

104. Yuen further emphasizes the importance of having a watertight seal of the device. *See, e.g.*, 15:1-4 ("structural integrity of the device while accommodating watertight seal for the sensor package"), 20:52-64 ("prevents and/or minimizes water and other liquids penetration into the device housing"). Yuen describes that its "package or module of the optical sensor would be connected to the device with a pressure sensitive adhesive and a liquid gasket. (See, FIG. 7). Screws, rivets or the like may also be used, for example, if a stronger or more durable connection is required between the optical sensor package/module and the device body. Notably, the present inventions may also use watertight glues, hydrophobic membranes such as Gore-Tex, O-rings, sealant, grease, or epoxy to secure or attach the optical sensor package/module and the device body." Ex-1006, 15:5-14.

105. Numerous other examples of the types of coatings that may be used to cover electronics in an electronic device are taught in the art. *See, e.g.*, Ex-1034, 4:54-5:2 (Asada '199) ("Lightweight cover 25 is preferably made of cast acrylic.

The inner diameter widens to couple to base unit. The main function of the cover is to protect the sensors from outside elements. Base unit 23 is preferably made of the same cast acrylic material as cover 25 and has a tolerance to provide a secure fit by means of friction. Moreover, this component aids in shielding the ambient light, which the cover unit could not handle."); Ex-1026, 4:47-55 (Hannula) ("In one embodiment of the present invention, the inner side 125 of layer 112 is covered with a laminated opaque film. The opaque film blocks ambient light that may interfere with photodetector 116. The opaque film may comprise polyethylene. The opaque film may be black or some other dark color that helps block ambient light and reduces shunted light. Dark in color is understood here to be of a nature with little reflectance of the wavelengths of light sensed by the sensor's photodetector."); Ex-1028, 1:46-50 (Kimura) ("A surface treatment (such as painting black) for preventing the reflection of light has been caried out on the inside of this attachable device 1. The sensor 2 has a light-emitting diode 22 and a photo diode 23 mounted in a package 21 molded inside the attachable device 1."); Ex-1029, 0013 (Tremper) ("Clinically, ambient light artifact can be minimized by covering the sensor with an opaque shield."); Ex-1057, 1807 (Ross) (Liquid Crystal Polymer (LCP) was known to be a "class of high performance, high temperature thermoplastic polymers which can be formulated to provide injection molding compounds having properties uniquely advantageous for electronic cavity

packages. … [T]his polymer class, together with ancillary materials such as metal leadframes and adhesives, … combine to produce a range of cavity package configurations that can compete in the same performance arena as ceramics." Ex-1057, 1807 (Ross); Ex-1055, 78 (Ardebili) ("Coloring agents are added to the molding compound to distinguish between different device types in packages and eliminate device visibility through the normally pale yellow epoxy encapsulant. The colors are produced by the addition of thermally stable organic dyes or pigments.").

3. Windows and transparent materials were commonly used for emission and detection

a. Windows for optical transmission, such as light emission and detection

106. As discussed further below, optical sensors are used to obtain continuous measurements of a patient/user's biometric data. For example, U.S. Patent No. 4,880,304 to Jaeb et al. ("Jaeb") explains how "it is extremely important to be able to obtain continuous measurements of a patient's tissue oxygenation" Ex-1042, 1:15-17. Jaeb notes that although an actual blood sample is considered the most accurate method, it is "undesirable in cases where it is necessary to monitor blood oxygen saturation over long periods of time." *Id*., 1:20-34. Therefore, Jaeb disclosed how a noninvasive oximeter "capable of detecting significant changes in the blood oxygen content would be especially useful." *Id*.,

1:31-34. Jaeb taught a "optical sensor which has increased sensitivity, and which is resistant to the effects of ambient light" by having the sensor housing having "central protrusion in which a plurality of light emitting diodes and an optical sensor are mounted in a vertical configuration." *Id*., 2:49-53. This allows the sensor to be placed on the patient's tissue so that the "sensor face containing the LEDs and detector protrudes slightly into the tissue" "thereby increasing the signal strength of the detected signal." *Id*., 3:54-65, 5:13-17. Therefore, the sensor face is directly exposed to the user's skin.

107. Jaeb explains that the placement of the LEDs and sensor is important to prevent problems related to signal strength and susceptibility to interference. *See, e.g.*, Ex-1042, 4:59-62. For example, as shown in Figure 2B, when the "lower face of the housing 12 contains LEDs 16 and 18 which emit light in the red and infrared spectra, respectively, and an optical sensor 20 for detecting light reflected by subsurface tissue" causes issues of interference by "by ambient light entering from the perimeter of the sensor housing." *Id*., 4:51-58, 5:1-3.

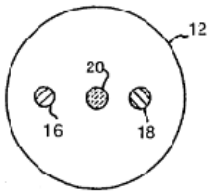


FIG. 2a

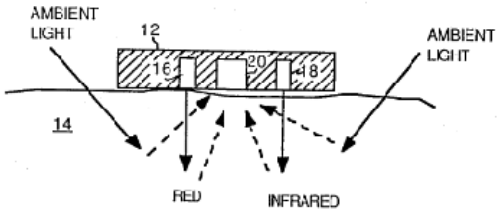


FIG. 2b

108. Jaeb explains and shows in Figures 3a and 3B that a light absorbing pad 30 can be attached to the lower face of the sensor to reduce "Interference due to ambient light entering from the edges of the sensor." Ex-1042, 5:17-21. However, Jaeb further explains that "[i]nterference due to ambient light is further reduced by recessing the LEDs 16, 18 and the detector 20 within the housing and by coating the respective LEDs with a polymer sealant 32. The coating provides improved optical index matching and also provides an electrical and biological seal between the sensor and the tissue." *Id*., 5:21-27.

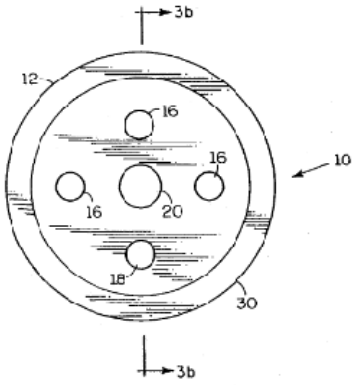


FIG. 3a

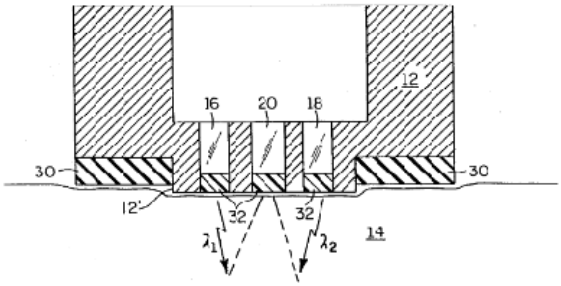


FIG. 3b

109. U.S. Patent No. 8,954,135 to Yuen (Ex-1006) is another example of using transparent material over LED sensors. Yuen acquires the user's biometric data by light from optical sensors, or LEDs, emitted through a "window" made of "plastic or a glass layer." Ex-1006, 10:55-66. Specifically, Yuen describes a window "in the housing to facilitate optical transmission between the optical sensors and the user." *Id*. The window permits the light to be emitted by one "or more LEDs, onto the skin of the user and a response or reflection to pass into the housing to be sampled, measured and/or detected by, for example, one or more photodiodes." *Id*.; *see also id.*, Claim 6 ("the window includes a first portion having first optical properties and a second portion having second optical properties different from the first optical properties.").

110. Yuen discusses three light sources separate from one another emitting

different wavelengths of light: "an LED that emits light having wave lengths corresponding to the green spectrum," "an LED that emits light having wavelengths corresponding to the red spectrum," and "an LED that emits light having wavelengths corresponding to the IR spectrum." Ex-1006, 10:29-31, 10:34-39. Yuen's biometric monitoring device has optical sensors "arranged on the skin side" so light is emitted upon the user's skin and detected by a light detector to measure a "user's heart rate, respiration, heart rate variability, oxygen saturation (SpO2), blood volume, blood glucose, skin moisture and/or skin pigmentation level." Ex-1006, 10:7-21. In this situation there are thus multiple windows for each LED. Yuen claims "the window includes a first portion having first optical properties and a second portion having second optical properties different from the first optical properties" where the "the first portion of the window and the third portion of the window are spaced apart and separated by the second portion of the window." *Id*., Claims 6, 11.

111. Yuen explains that its optical window can be in the form of a protrusion also:

> The light emitter(s) and/or detector(s) of the optical sensor may be disposed or arranged in the protrusion juxtaposed the window or light transmissive structure. As such, when attached to the user's body, ***the window portion of the protrusion*** of the biometric monitoring device engages the user's skin with more force than the surrounding device body—thereby providing a more secure physical connection between the user's skin and the

> optical window. That is, a protrusion improves sustained and/or fixed contact between the biometric monitoring device and the user's skin (for example, the skin of a predetermined portion of the user's body) which may reduce the amount of stray light measured by the photodetector, decrease motion between the biometric monitoring device and the user, and/or provide improved local pressure to the user's skin; all of which may increase the quality of the cardiac signal of interest.

Ex-1006, 13:39-62.

112. Yuen explains that the windows can also be used on the exterior of the housing. As shown in Figure 12 below, an "optical heart rate monitor … disposed or located on one or more external or environmental side surfaces of the biometric monitoring device." Ex-1006, 12:62-65. "The user may touch an optical window (behind which optical elements of the optical heart rate monitor are located) with a finger on the opposing hand to initiate a heart rate measurement (and/or other metrics related to heart rate such as heart rate variability) and/or collect data which may be used to determine the user's heart rate (and/or other metrics related to heart rate)." Ex-1006, 12:65-13:5.

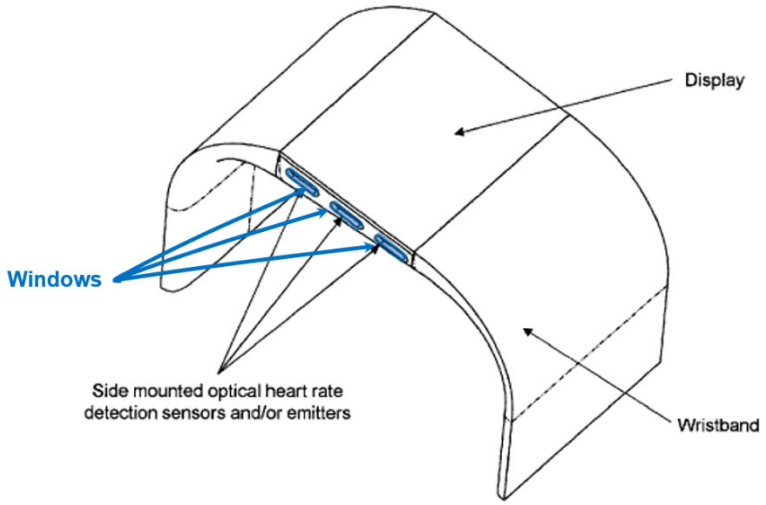


FIG. 12

113. Yuen explains that the light transmissive structure has an "optically opaque portion (including certain optical properties) and an optically transparent portion (including optical properties different from the optically opaque portion." Ex-1006, 11:49-33. Such a structure is provided by a "double-shot or two step molding process wherein optically opaque material is injected, and optically transparent material is injected" to form a "light transmissive structure having an optically opaque portion (including certain optical properties) and an optically transparent portion (including optical properties different from the optically opaque portion)." Ex-1006, 11:33-36. This allows the windows to have "different transmissive properties for different wavelengths depending on the direction of light travel through the structure. For example, in one embodiment, the optically opaque material may include a property of being reflective to a specific

wavelength range so as to more efficiently transport light from the light emitter(s) and from the user's body back to and detected by the detector (which may be of a different wavelength(s) relative to the wavelength(s) of the emitted light)." Ex-1006, 11:36-46; *see also id*., Claims 7-8 (the windows can be "optically opaque" to certain wavelengths, such as light in the visible spectrum).

114. U.S. Patent Publication No. 20130211291 to Tran ("Tran," Ex-1045) also discusses an "optical heartbeat detector" with an "optical transducer is positioned on a finger, wrist, or ear lobe." Ex-1045 ¶295. In the finger pulse oximeter, Tran's device "emits lights from a window in the infrared spectrum and receives reflected light in a second window. When the heart beats, blood flow increases temporarily and more red blood cells flow through the windows, which increases the light reflected back to the detector. The light can be reflected, refracted, scattered, and absorbed by one or more detectors. Suitable noise reduction is done, and the resulting optical waveform is captured by the CPU." Ex-1045 ¶295.

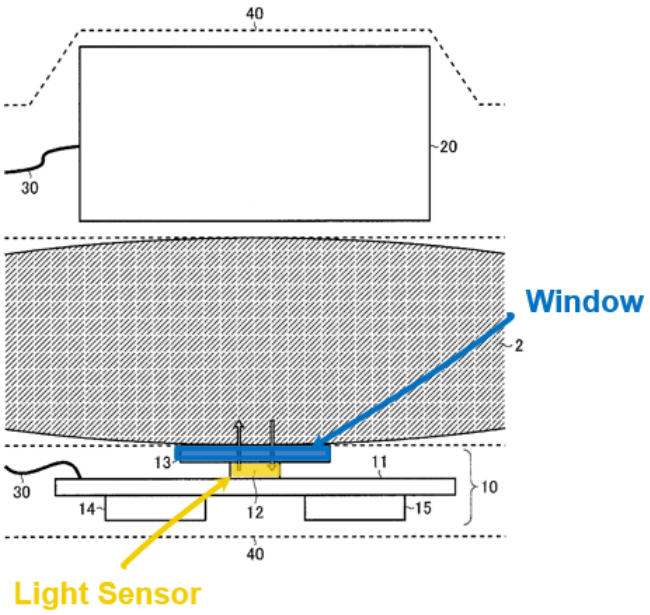
115. U.S. Patent Publication No. 20120016245 to Niwa ("Niwa," Ex-1005) is another example of using a transparent window. Niwa teaches a wearable electronic sensing device with light-emitting and light-receiving components to acquire a plethysmogram—e.g., information relating to blood volume—of the wearer. *See* Ex-1005. Niwa teaches a ring-shaped device that surrounds "the ball

side of the finger 2 (i.e., palm side) when the finger ring type housing 40 is worn" for the plethysmogram measurement. Ex-1005 ¶192.

116. As shown in Figure 27, Niwa shows a "measurement window 13." Specifically, Niwa's finger ring has a first unit 10 which is a "unit to measure the plethysmogram mainly, which is contained within the finger ring type housing 40 to be set to the ball side of the finger 2 (i.e., palm side) when the finger ring type housing 40 is worn on the third joint of the third joint of the finger 2." *Id*. The first unit 10 is supplied with power from the second unit 20. Ex-1005 ¶193. The first unit 10 includes "substrate 11, a light sensor 12, an amplifier circuit 14, and a processing circuit 15" and a "translucency portion which forms the measurement window 13." Ex-1005 ¶200. The measurement window is provided at the light emitting/receiving surface of the light sensor." Ex-1005 ¶30. Niwa discusses that the measurement window 13 is made "with the translucency portion (i.e., a glass plate or an acrylic plate) which is provided at the light emitting/receiving surface of the light sensor 12" in order for the light sensor 12 "to perform measurement of the plethysmogram (i.e., detection for the emitted light to the finger 2 and a reflected light go back from the finger 2) via this measurement window 13." Ex-1005 ¶210. The thickness of the measurement window 13 depends on the design "in view of the depth of focus of the light sensor 12." *Id*. As shown below in Figure 27, the measurement window (blue) allows for the light to be emitted from

the light emitting portion (yellow) to the user's finger when pressed to the measurement window. Ex-1005 ¶117.

FIG.27



117. Similarly, WO2001017421A1 ("Lindberg") (filed Sept. 7, 2000), explains using "transparent silicone" over the light sources and detectors. Lindberg relates to a non-invasive method for determination of SpO_2 by:

> a) directing light beams against the mixture;
> b) determining at least one blood characteristic other than Sp02 including hemoglobin of the mixture by analyzing the intensity of the light reflected from the mixture, or the intensity of the light reflected from the mixture in combination with the intensity of the light transmitted through the mixture; and
> c) determining oxygen saturation, Sp02, of the mixture by analyzing the intensity of the light transmitted through the mixture.

Ex-1046, 0005 (page numbered 4).

118. Lindberg directs light beams using "light sources" comprising of a first light source for emitting a first light beam with a wavelength in the red light range and a second light source for emitting a second light beam in the infrared light range. Ex-1046, 0007 (page numbered 6); *see also id*., 0010 (page 9) (explaining that the light sources may be light emitting diodes). The apparatus comprises a first detector for detecting the intensity of the light of the red light beam and a second detector for detecting the light form the infrared light beam. Ex-1046, 0007 (page numbered 6). Lindberg explains that when using the light sources and detectors "for reflection" they are incorporated and covered with transparent silicone. *Id*., 0020 (page numbered 9). Therefore Lindberg describes using a transparent material such as silicone over the LEDs.

119. WO 2011/132009 to Nyriradi (Ex-1047) is another example of having an LED under a translucent material. Specifically, Nyriardi teaches a "driving indicator with LED integrated in bracelet for cyclists and motorcyclists." Ex-1047, 0002. The bracelet can have a "plastic arm strap 11" made of a "transparent, translucent version of the special plastic" so that it "becomes possible for the light of the LED 4 placed into [t]he plastic arm strap 11 itself to penetrate the material of the plastic arm strap 11." Ex-1047, 0012 (numbered page 11).

120. Therefore, windows and transparent materials for optical transmission

were well-known in order to focus the light from a light-emitting component, such as a light emitting diode, to be emitted through and reflected back to the light receiving component, such as a photodetector.

b. Windows for RF transmission and detection

121. Windows were also commonly used for radio frequency transmission. For example, U.S. Patent Application Publication No. 2012/0218184 to Wissmar (Ex-1013), teaches an electronic finger ring with electronic components packaged and integrated within the ring for radio frequency (RF) transmission. Ex-1013, Abstract. Wissmar's finger ring is a toroidal shaped finger ring structure, "constituted of two different metallic shells: (i). 1 a, made of gold (Au) or silver (Ag), enclosing the major parts of the finger ring structure geometrically described as radially furthest away from the toroids centre, and (ii). 1 b, made of a titanium compound (Ti, TiW), being the metal enclosing facing the inner parts of the finger ring structure." Ex-1013 ¶73.

122. As shown below in Figure 1, the "toroidal shaped finger ring structure 1 is comprised of different electronic components: a battery 2, a RF transceiver 3 and a micro processor 4, a microstrip line 5, an accelerometer 6, an internal antenna 7, a pressure sensor 8; all mounted on a flexible printed circuit board 9. In this embodiment, there is also an outer metal shell opening 10 serving as an RF window letting through unperturbed RF radiation." Ex-1013 ¶73. All electronic

components, including "an antenna," are mounted on a flexible printed circuit board (FPCB). Ex-1013 ¶¶71, 91. The antenna is specifically "located under the portion of the ring which has no outer shell metal" to allow "unperturbed RF radiation" when the outer shell is made of a metal that would otherwise prevent RF radiation from passing. Ex-1013 ¶91.

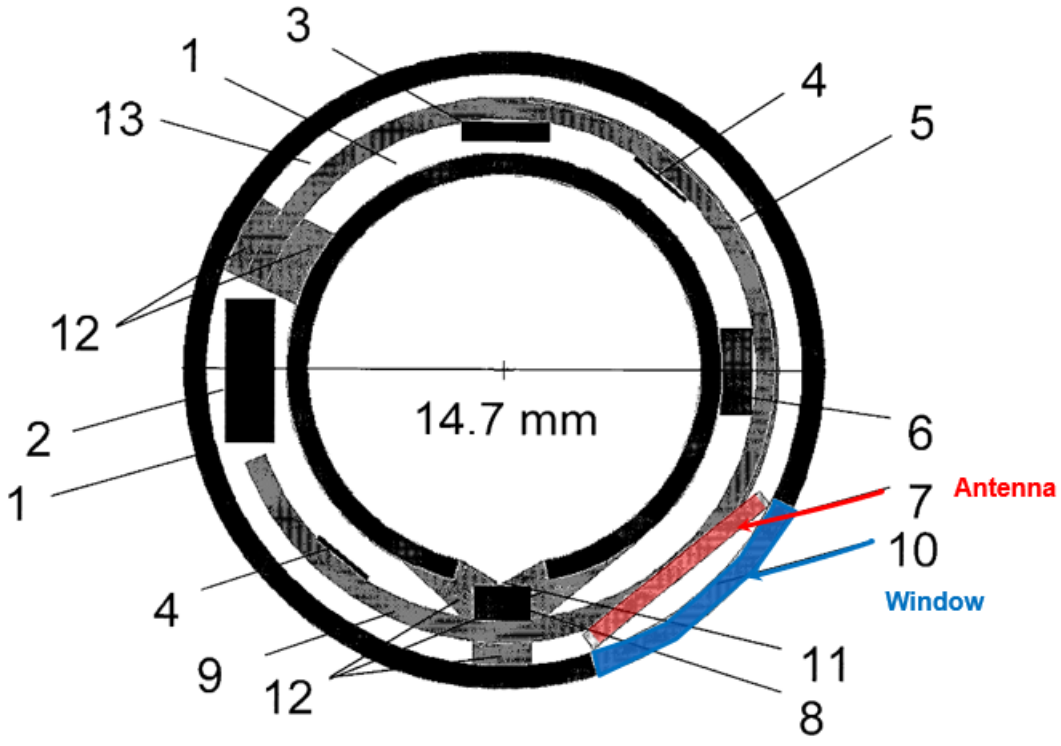


Fig. 1

123. Similarly, U.S. Patent Application Publication No. 2014/0361945A1 to Misra et al. ("Misra," Ex-1048) explicitly teaches a radio-frequency transparent window from 2013. Specifically, Misra explains that antenna architecture is an "integral part of portable electronic devices" and how housings and structural components are often made from conductive metals, which can serve as a ground

for an antenna. Ex-1048 ¶2. However, "nonconductive regions that are transparent to radio-frequency (RF) radiation … provide a good radiation pattern and signal strength" such as conventional "antenna windows in portable electronic devices include a plastic antenna window or a plastic split in a housing forming a gap in the conductive metal." *Id.* Misra explains that the break in cosmetic metal surface "breaks the consistent visual profile," so that POSITAs desired "an RF transparent window that provides good signal quality to an antenna inside the housing of a portable electronic device while also providing structural support and visual consistency to the housing." *Id*. ¶3. Misra provides a patch for a device in an electronic housing that has a thickness to provide a selected radio-frequency transmissivity and structural support. *See, e.g., id*. ¶¶4-8. Therefore, Misra provided an antenna window to provide radio frequency transmissivity.

124. Moreover, U.S. Patent Application Publication No. 2014/0361934 to Ely et al. ("Ely," Ex-1049) describes an electronic device house with a "window aligned with the radio-frequency (RF) antenna. Ex-1049 ¶5. Ely describes how antenna windows in aluminum enclosures are challenging. *Id*. ¶31. Ely provides a solution by providing a window that "non-conductive material filling a gap in the aluminum layer and a thin aluminum oxide layer adjacent to the aluminum layer and to the non-conductive material. The non-conductive material and the thin aluminum oxide layer form an RF-transparent path to allow transmission of

substantially all RF radiation through the window." *Id*. In order to make the window, Ely explains that the process includes "anodization of the exterior housing and then etching away on the interior of the housing antenna windows at desired locations for antenna windows, followed by filling in the etched portions with plastic, paint, or other suitable material to maintain structural integrity. The aluminum oxide can be substantially clear or transparent, allowing the filling material to show through. The resulting housing is cosmetically pleasing and without cracks or apparent plastic portions." *Id*. ¶31. The window in the aluminum housing "allows transmission of substantially all RF radiation through the window portion." *Id*. ¶7. Ely describes how the antenna windows may not only have the antenna but also have other sensors included in the electronic device. *Id*. ¶¶33, 40, 51.

125. In summary, windows in electronic device housings are particularly helpful for RF transmission.

D. Adjustment of Operational Parameters Was Known

126. Adjusting a sensor's operational parameters or measurement periodicity based on information from a sensor or battery was well known prior to 2013.

127. For example, European Patent No. 2281205 to Chen ("Chen," Ex-1050) discusses "general principles that can reduce the power consumption" of a

sensor system, including using passive sensors to detect activity to then turn on other sensors and varying the sampling rate of sensors "depending on the current state"—e.g., "when little or no motion is occurring." Ex-1050 ¶33. Chen describes a system that "selectively provide[s] power to one or more other sensors and/or process in response to" a sensor detecting "motion of a user." *Id.* ¶14. Chen further explains that "power consumption of the system is significantly reduced (and hence the battery lifetime is increased) during periods when there is no or little motion." *Id.* ¶15; *see also id.* ¶20 ("Preferably, the system is configured to stop power being supplied to one or more of the other sensors and processor in the event that the passive vibration sensor detects that the motion has ceased."). Chen also describes "increas[ing] a sampling rate of the one or more sensors in response to the passive vibration sensor detecting motion." *Id.* ¶22; *see id.* ¶33 ("[T]he sampling rate of the sensors can be varied depending on the current state in order to minimize the power consumption when little or no motion is occurring."). Thus, adjusting a sensor's measurement periodicity was also routine in monitoring applications.

128. For example, as explained in 2009 by Lawrence Au, "[e]nergy efficiency presents a critical design challenge in wireless, wearable sensor technology." Ex-1051, Abstract. Au explains that to maximize monitoring system's lifetime and maintain accuracy, "wearable sensors require hardware

support that allows dynamic power control on the sensors … as well as monitoring algorithms to control these components intelligently." *Id.* Au suggested using "episodic sampling, … a context-aware scheduling technique where context classification occurs only episodically," rather than the "traditional continuous sampling." *Id.*, 2. For example, the experiment performed in Au compared episodic sampling against continuous sampling for both low-dynamic activity ("rest") and high-dynamic activity ("running"). *Id.*, 4. The experiment classified the activity based on measurements from a heart rate sensor, respiratory sensor, and wearable accelerometer. *Id.*, 4, Fig. 1. In some instances, episodic sampling extended battery life. *Id.*, 4, Fig. 5.

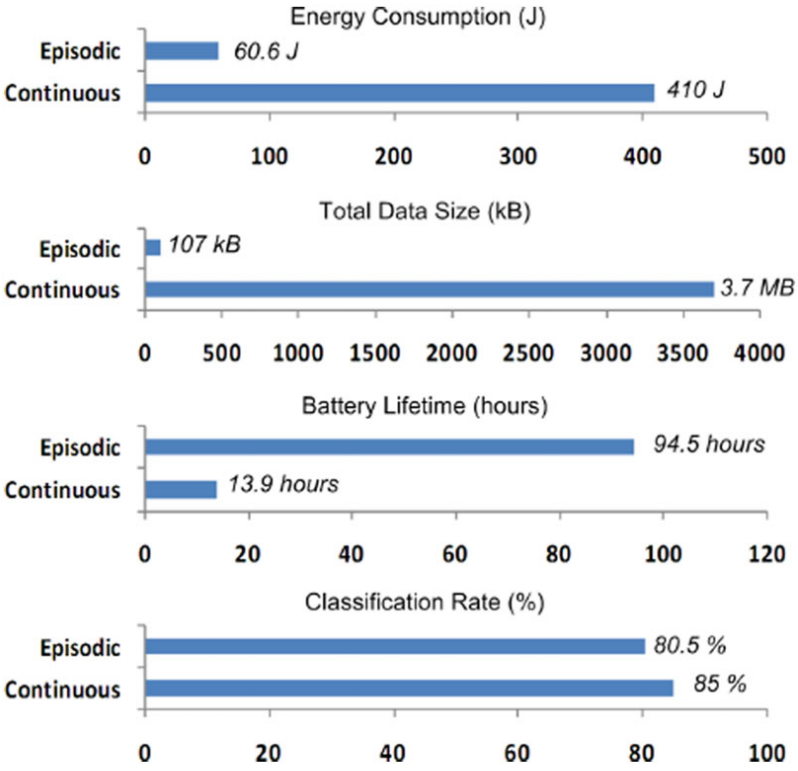


Fig. 5.
Experimental Results - Continuous vs. Episodic Sampling

Thus, adjusting measurement periodicity was known in wireless healthcare applications.

129. Therefore, it was well-known adjusting a sensor's operational parameters or measurement periodicity based on a user's activity or sensor information could reduce power consumption of a device.

VI. CLAIM CONSTRUCTION

130. I do not believe that any claim term requires explicit construction to resolve the issues presented in the Petition. I apply the plain and ordinary meaning to each claim term, as that plain and ordinary meaning would have been understood by a POSITA.

131. I reserve the right to offer opinions on any claim constructions proposed in this proceeding or to offer opinions on additional constructions in the district court.

VII. BRIEF DESCRIPTION OF THE APPLIED PRIOR ART REFERENCES

A. Niwa (Ex-1005)

132. Niwa (U.S. Patent Publication No. 2012/0016245) was filed July 13, 2011, and published January 19, 2012. As explained to me by my counsel, I understand that Niwa qualifies as prior art under at least 35 U.S.C. §102(a)(1) and §102(a)(2).

133. Niwa teaches a wearable electronic sensing device with light-emitting

and light-receiving components to acquire a plethysmogram—e.g., information relating to blood volume—of the wearer. *See* Ex-1005. Figures 22 and 26 depict Niwa's ring-shaped device that surrounds "the ball side of the finger 2 (i.e., palm side) when the finger ring type housing 40 is worn" for the plethysmogram measurement. Ex-1005 ¶192.

FIG.22

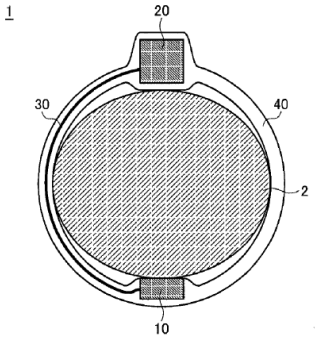
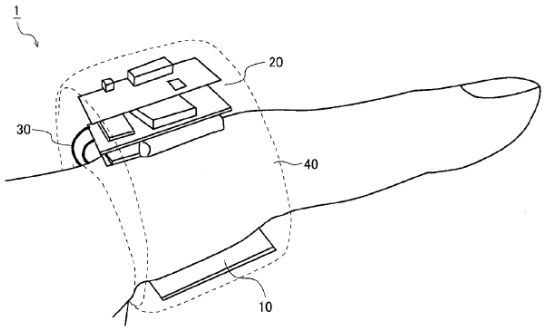


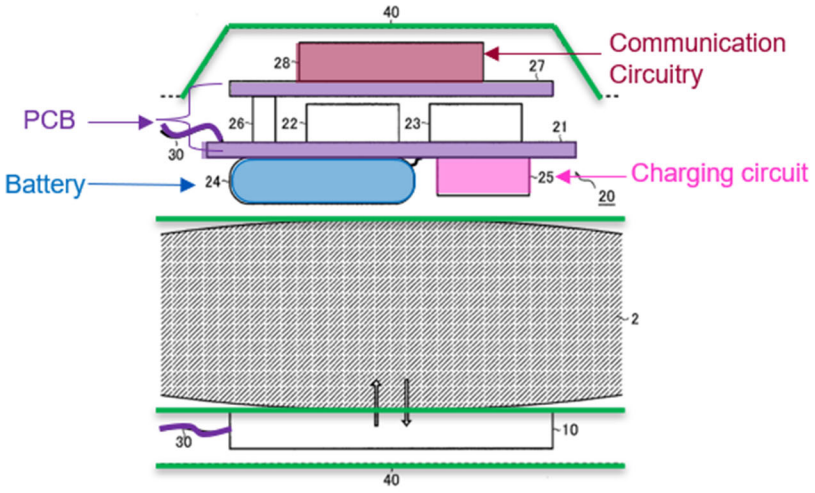
FIG.26



Id., Figs. 22, 26.

134. As shown in Figure 28, cable 30 (purple) is disposed within finger ring type housing 40 to electrically connect first unit 10 and second unit 20. Ex-1005 ¶¶62, 194-95. Cable 30 may be a "FPC [Flexible Printed Circuits]." *Id*. ¶194. Second unit 20 "supplies" power to the first unit and includes battery 24 which is charged from an outside energy source by charging circuit 25. *Id*. ¶¶62, 193, 213, 218.

FIG.28

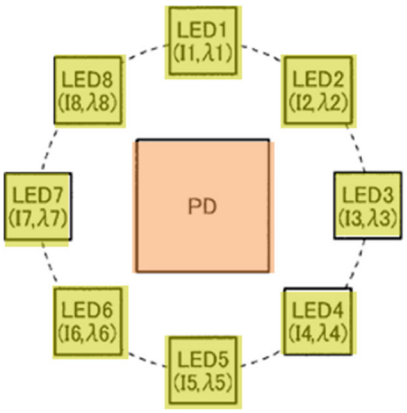


Id., Fig. 28.[2]

135. Niwa also teaches various configurations for light-emitting portions (e.g., wavelengths) and light-receiving portions (e.g., positions) in the first unit 10. Ex-1005 ¶¶120, 147. As shown in Figure 3, each LED is associated with an output wave length denoted as ***λ1*** to ***λ8*** and are values different from one another and each LED is placed at different radial positions. *Id.* ¶147.

[2] Throughout this Declaration, all annotations and emphasis have been added, unless otherwise noted.

FIG.3



Id., Fig. 3.

B. Yuen (Ex-1006)

136. Yuen (U.S. Patent No. 8,954,135) was filed June 24, 2013, and issued February 10, 2015. As explained to me by my counsel, I understand that Yuen qualifies as prior art under at least 35 U.S.C. §102(a)(2).

137. Yuen teaches a biometric monitoring device, depicted in Figure 4 below, configured to be worn on an appendage of the user's body, for example, on the user's "arm, wrist, leg and/or ankle." Ex-1006, 12:50-52. Yuen biometric monitoring device has a housing (green) that "may [] consist of a metal material (for example, steel, stainless steel, aluminum, magnesium, or titanium)." *Id*., 14:33-37.

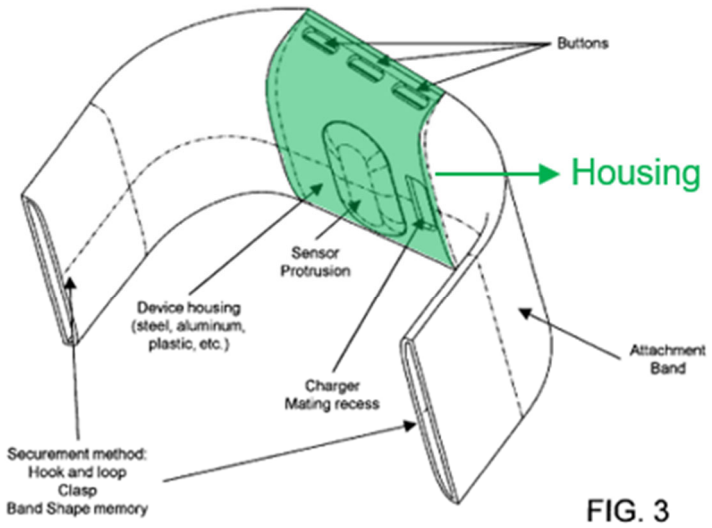


FIG. 3

138. *Id*., Fig. 3. Inside the housing of Yuen's device is "an optical sensor having one or more light sources" (such as LEDs) that emit "light into the user's body" and light detectors (such as photodiodes and/or phototransistors) that "sample, measure and/or detect a response or reflection" from the user's body, which is used by a PPG [photoplethysmography] to determine the user's stress level, blood pressure and/or heart rate. *Id*., 6:23-31. The LEDs, photodetectors, and other electronics may be provided on a [regular] or a flexible PCB. *Id*., 2:38-39, 12:35-42.

139. As shown in Figure 11, Yuen further describes "a plurality of photodetectors and photoemitters [yellow] placed along the circumference of the interior of the band." Ex-1006, 19:8-10.

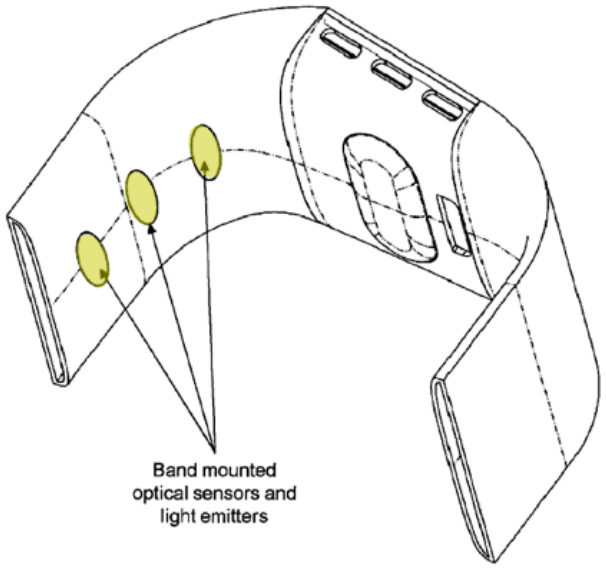


FIG. 11

Ex-1006, Fig. 11.

C. Schröder (Ex-1007)

140. Schröder (U.S. Patent No. 10,303,867) was filed January 25, 2016 as the U.S. national stage application of International Patent Application PCT/EP2014/001693 filed June 18, 2014, which claims priority to foreign application DE 102013012339 filed July 25, 2013. As explained to me by my counsel, I understand that Schröder qualifies as prior art under 35 U.S.C. §102(a)(2). Schröder's German counterpart is essentially identical to the U.S. filing. *See generally* Ex-1007 (U.S. issued patent); Ex-1009 (German application); Ex-1008 (certified translation of German application). The figures are identical, and the specification is equivalent. Because the described subject matter is identical, as explained to me by my counsel, I understand that Schröder's '867

Patent should be considered to have been effectively filed as of its German priority date of July 25, 2013, because the '867 Patent is entitled to claim a right of priority to DE 102013012339 under §365.

141. Schröder teaches a biometric sensing device, depicted in Figures 1 and 5 below, which is a finger-ring "worn by a user, e.g. permanently on the finger." Ex-1007, 3:61-63,[3] Fig. 1 (finger-ring 2 communicating with smartphone 4); Ex-1008, 8:4-5, Fig. 1.

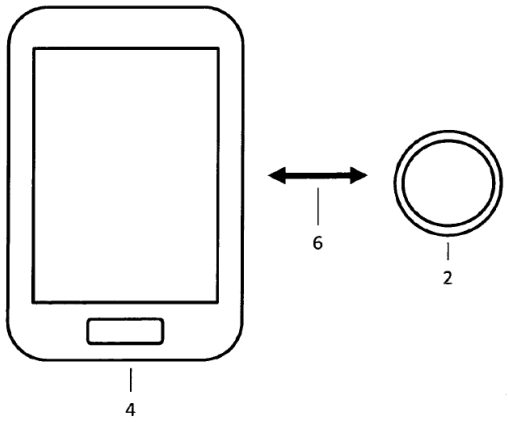


Fig. 1

142. As shown in Figure 7 below, Schröder's finger-ring consists of "two ring halves 16 and 18" with a recess so that "inlay 12 is inserted." Ex-1007, 12:7-9. Inlay 12 consists of "flexible carrier material" like PET and Kapton (*id*., 12:28-29) and can have a "chip module 10 with at least one antenna coil 8." *Id*., 12:61-65. Schröder explains that a battery powers chip module 10 and is charged

[3] Parallel citations to Schröder's German counterpart for all Schröder '867 Patent citations herein are provided in Ex-1022.

wirelessly. *Id*., 11:46-50, 11:55-56. Schröder's finger-ring also has "biometric sensors" such as an infrared diode and sensor to "capture [] e.g., at least a partial vein image in the finger while the finger-ring 2 is being pushed over a finger." *Id*., 9:62-10:4.

Fig. 7

VIII. DETAILED EXPLANATION OF THE UNPATENTABILITY GROUNDS

A. Ground 1: Claims 1-5 and 11-16 Are Obvious Over Niwa (Ex-1005)

1. Independent Claim 1

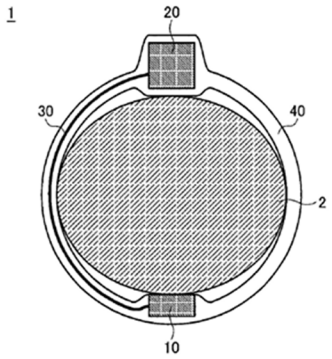
a. Element 1[pre]: A wearable computing device, comprising:

143. Niwa teaches[4] the preamble of Claim 1, to the extent it is limiting.

144. As shown in Figure 22 below, Niwa's plethysmogram sensor 1 has a "finger ring construction" to be "worn on the third joint of the finger 2." Ex-1005 ¶191.

[4] I use the term teaches, which I understand from Counsel includes both express teachings or those fairly suggested to a person of ordinary skill in the art.

FIG.22



Id., Fig. 22.

b. Element 1[a]: a housing comprising an interior wall and an exterior wall of the wearable computing device

145. Niwa teaches Element 1[a].

146. As shown in Figures 22 and 27, Niwa's plethysmogram sensor provides a "finger ring type housing 40 [green]." Ex-1005 ¶191. The finger ring housing has an interior wall that surrounds "the ball side of the finger 2 (i.e., palm side) when the finger ring type housing 40 is worn" for the plethysmogram measurement. Ex-1005 ¶192. Niwa explains that the finger ring housing "cover[s]" the interior components within the ring. Ex-1005 ¶201. A POSITA would have understood that the wall surrounding finger 2 is the interior wall and the wall exposed to the environment, the outward facing surface of housing 40, is the exterior wall. Accordingly, Niwa's plethysmogram sensor provides a finger

ring type housing with an interior wall and exterior wall.

147. A POSITA would have clearly understood that the wall encircling finger 2 constitutes the interior wall of the device, which is primarily oriented towards and in contact with the body part it surrounds. This interior wall serves crucial functional roles, including maintaining the correct positioning of the device on the finger and protecting the internal components from direct contact with the skin. Similarly, a POSITA would have clearly understood that the wall that is exposed to the environment, the outward facing surface of housing 40, is the exterior wall. This exterior wall is crucial for shielding the device from external elements and physical impacts, ensuring durability of the device. A POSITA would recognize that this exterior wall also potentially interacts with variable environmental conditions such as temperature, humidity, and mechanical stress, necessitating robust materials and design considerations to maintain the device's integrity and performance over time.

FIG.22

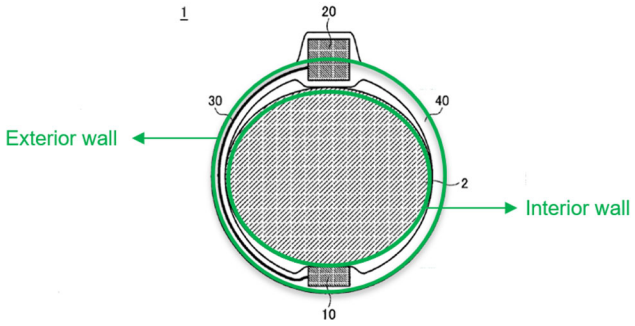
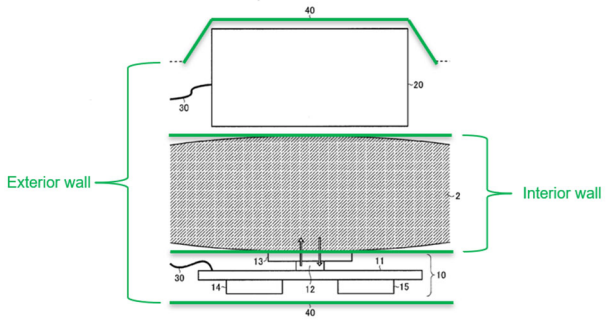


FIG.27



Id., Figs. 22, 27.

148. Further, as I discussed in Section V.B.1, a finger-ring construction with inner and outer walls with electronics housed inside the ring were well-known.

c. Element 1[b]: a printed circuit board disposed within the housing;

149. Niwa teaches Element 1[b].

150. As shown in Figures 27 and 28, Niwa's substrates (purple) are printed circuit boards with various sensors and circuits "equipped" to their surfaces. Ex-

1005 ¶¶69, 200, 214, 219. Moreover, cable 30 "include[s]…, FPC [Flexible Printed Circuits]" and is connected to the substrates to establish an electrical connection between first unit 10 and second unit 20 "contained within the finger ring type housing 40." Ex-1005 ¶¶29, 62, 194-95.

FIG.27

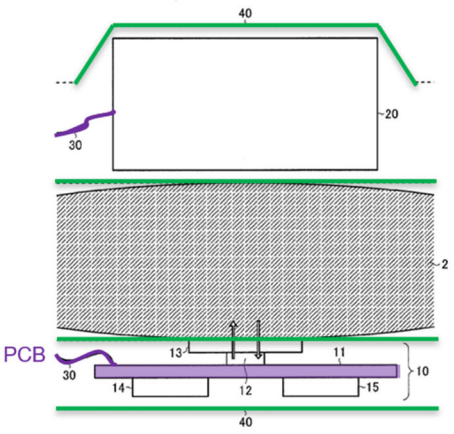
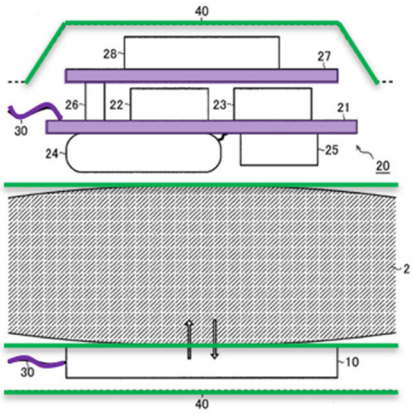


FIG.28



Id., Figs. 27, 28.

151. As I discussed in Section V.B.4, using printed circuit boards in electronics with space constraints was well-known. A POSITA would have understood that "substrate" in this context to refer to a circuit board based on several cues from the description provided. For example, Niwa specifies that the light sensor, amplifier circuit, and processing circuit are mounted directly to the surface or back side of the substrate. This direct attachment of electronic components is characteristic of a printed circuit board (PCB), which is commonly used as a mounting surface in electronic devices due to its ability to provide both

physical support and electrical connections for components. The presence of a cable connected to the substrate to establish an electrical connection with another unit, and the use of through holes and via holes to establish connections between the surface and back side of the substrate, further supports the interpretation of the substrate as a PCB. These features are typical of PCBs, which are designed to facilitate complex electrical pathways and connectivity within a compact space. These elements combined—direct mounting of components, sophisticated electrical connectivity, emphasis on compactness, and strategic component placement for functionality—clearly align with the characteristics of a PCB, leading a POSITA to understand that the substrate mentioned is indeed a printed circuit board.

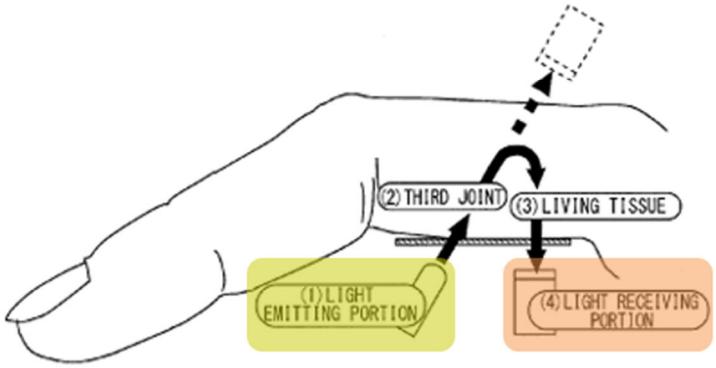
d. Element 1[c(i)]: a plurality of sensors electrically coupled with the printed circuit board, the plurality of sensors configured to acquire data from a user, the plurality of sensors comprising:

152. Niwa teaches Element 1[c(i)].

153. As I discussed in Section V.A.1, photo-plethysmogram sensors were well known and used to measure changes in volume within the body of the user such as monitoring heart rate. As illustrated in Figure 21, Niwa's photo-plethysmogram has the light emitting portion at the third joint of the user's finger. Ex-1005 ¶117, *see also* Fig. 1. The finger is pressed against the measurement

window of the device and the light which penetrates the living tissue and is emitted out of the living tissue is detected at the light receiving portion. *Id*.

FIG.21



Id., Fig. 21.

154. Niwa's first unit 10, which measures the plethysmogram, has various sensors and circuits "mounted" to substrate 11 (purple) (the claimed printed circuit board). Ex-1005 ¶¶68-69, 194, 200, 214, 219.

155. As shown in Figures 3 and 27, Niwa's first unit 10 includes light sensor 12 to acquire data from a plurality of sensors "[b]y means of emitting the light from the ***light emitting portion*** to the third joint of the finger 2 and detect[ing] the intensity of the light which penetrates the living body by the ***light receiving portion***." *Id*. ¶209.

FIG.27

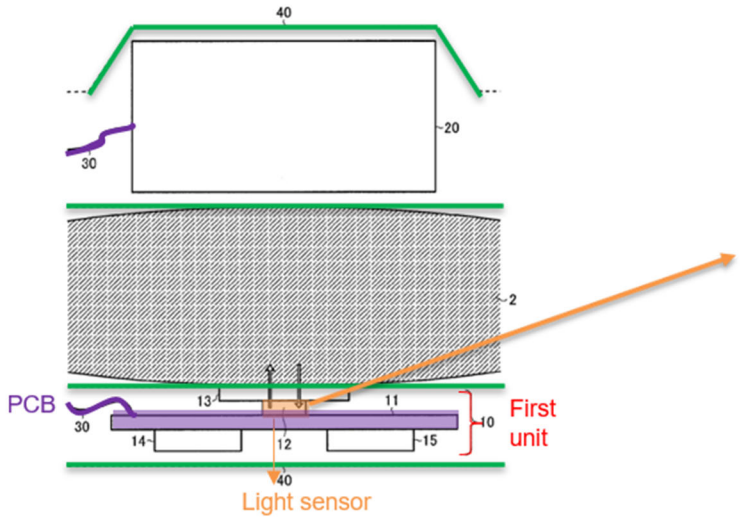
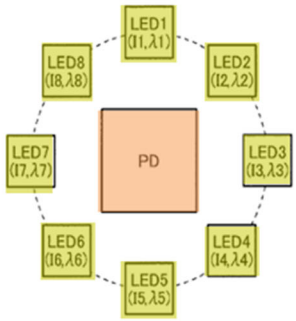


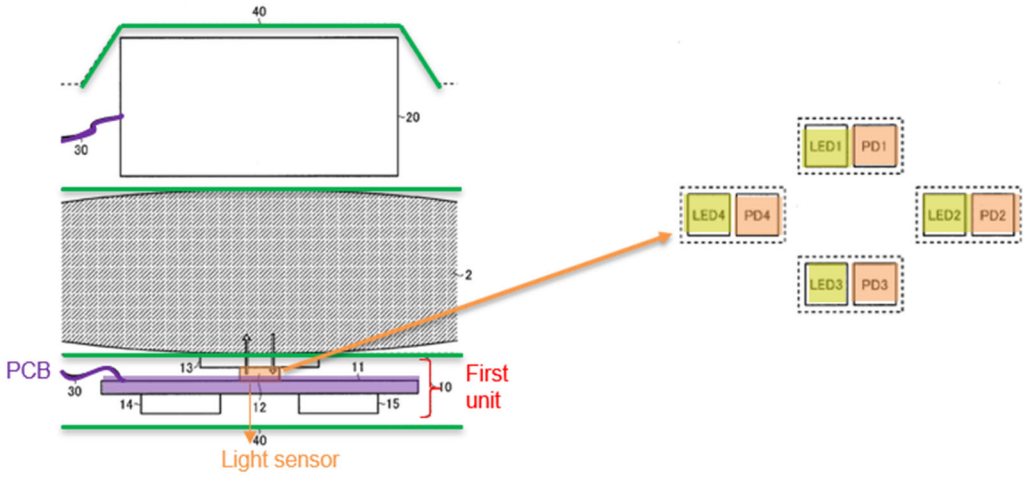
FIG.3



156. *Id*., Figs. 3, 27. Although Figure 3 shows the arrangement of one light sensor module 12, Niwa explains that module 12 is not restricted to this construction. *Id*. ¶164. Niwa teaches in Figure 14 that several light sensor modules (i.e., each surrounded by a dotted rectangle) can be provided at different locations, each module being constructed with the light emitting portion "LED#" and the light receiving portion "PD#" as shown in Figures 14 and 27. *Id*., *see also* Figs. 15A-16B.

FIG.27

FIG.14



Id., Figs. 14, 27

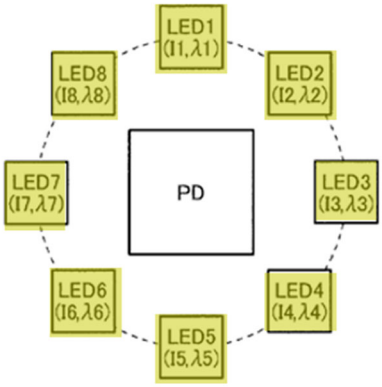
e. Element 1[c(ii)]: one or more light-emitting components configured to emit light associated with two or more wavelengths, wherein the two or more wavelengths include a first wavelength associated with infrared light and a second wavelength associated with visible light; and

157. Niwa teaches Element 1[c(ii)].

158. As I explained in the previous section, Niwa's light sensor 12 acquires data "[b]y means of emitting the light from the light emitting portion to the third joint of the finger 2 and detect[ing] the intensity of the light which penetrates the living body by the light receiving portion." Ex-1005 ¶209.

159. As shown below, Figure 3 illustrates the plethysmogram sensor with "both the light emitting portion and the light receiving portion provided at same side against the fingertip." *Id.* ¶120.

FIG.3



160. *Id*., Fig. 3. Niwa's light emitting portion has "eight light emitting portions LED1 to LED8 (i.e., a light emitting diode) [yellow] equally spaced from one another and placed on a circumference." *Id*. ¶120. Each LED is associated with an output wavelength denoted as ***λ1*** to ***λ8*** and "are values different from one another (i.e., from a visible light region to a near-infrared region)." *Id*. ¶147. A POSITA would have understood that Niwa's near-infrared LED emits infrared light because the infrared radiation of the electromagnetic spectrum is usually divided into three regions; the near-, mid- and far- infrared light.

161. As I previously explained, the plethysmogram sensors in Figure 3 can include several light sensor modules constructed with the light emitting portion LED and the light receiving portion PD provided at different places. Ex-1005

¶164. Niwa explains that "the number of the light emitting portions is simply an example" and a number other than eight can be adopted. *Id*. ¶120. In view of the non-limiting example, a POSITA would have understood that Niwa can have two or more LEDs that emit light at different wavelengths including visible light to near-infrared and can include an additional LED associated with infrared light to offset noise and improve the sensor's readings.

162. As I discussed in Section V.A.6, a POSITA would have also understood that using multiple LEDs emitting light at different wavelengths provide accurate and real-time information to the user about the user's health. Further, as discussed above in Section V.A.4, NIR wavelengths are used because oxyhemoglobin (O2Hb) and deoxyhemoglobin (Hb) have very distinct absorption spectra in the NIR wavelengths range. Additional LEDs improve redundancy in wearable electronic devices. Incorporating a large number of LEDs improves the redundancy of the device. If one LED fails, loses contact with the skin, or is occluded by a mole, scar, or other skin irregularities, the remaining LEDs can continue to function. This ensures that the device maintains its accuracy and reliability even in less-than-ideal conditions. Further, the presence of multiple LEDs creates several illumination paths. These multiple paths enable the device to take numerous measurements simultaneously, which significantly enhances the signal-to-noise ratio (SNR). A higher SNR translates to more accurate and reliable

readings.

163. U.S. Patent No. 7,468,036 to Rulkov et al. ("Rulkov") recommends a "greenlight LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight." Ex-1039, 6:56-58. Rulkov also uses multiple LEDs of green and infrared wavelengths, with a preferred embodiment in which the optical sensor includes "a plurality of light emitting diodes" ("LED") based on green light, and further describes monitoring vital signs in which "the plurality of light emitting diodes comprises a plurality of pulsed infrared light emitting diodes." *Id*., 6:49-58. A POSITA would have understood that multiple emitters each including multiple LEDs operating at different wavelengths advantageously provide "accurate" "real-time information to the user about the user's health" by, for example, enabling offset of noise affects. *Id*., 4:4-8.

164. Utilizing LEDs that emit light at a range of wavelengths allows the device to be more tolerant to variations in skin color. For example, different skin tones absorb light differently, and by using a broader spectrum of wavelengths, the device can account for these variations, ensuring consistent and accurate readings across diverse populations. A larger number of wavelengths enable the device to perform multiple estimations of the relative absorption between oxygenated and deoxygenated blood. Hemoglobin, the molecule responsible for carrying oxygen in the blood, has different absorption characteristics depending on whether it is

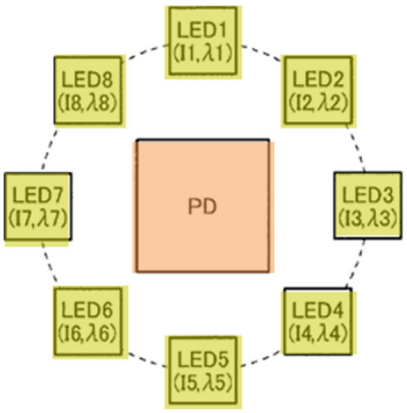
oxygenated or deoxygenated. By analyzing light absorption at multiple wavelengths, the device can more accurately determine the ratio of oxygenated to deoxygenated blood, thereby providing a more precise estimate of blood oxygenation levels.

f. Element 1[c(iii)] one or more light-receiving components configured to receive the light associated with the two or more wavelengths;

165. Niwa teaches Element 1[c(iii)].

166. As shown in Figure 3, Niwa's plethysmogram sensor "includes a single light receiving portion PD (i.e., a photo diode or a photo transistor) [orange]." Ex-1005 ¶120. Niwa's sensor receives light from the "eight light emitting portions LED1 to LED8 (i.e., a light emitting diode) [yellow] equally spaced from one another and placed on a circumference with a central focus on the light receiving portion PD." *Id*.

FIG.3



167. *Id*., Fig. 3. Niwa teaches that light receiving portion PD is configured to receive each wavelength of light associated with each of the LED1 to LED8 sequentially at intervals:

> [T]he light emitting portions LED1 to LED8 with different output wave lengths are turned ON sequentially for several laps, ***the intensities of the lights which penetrate the body emitted from the respective light emitting portions LED1 to LED8 and go back to the light receiving portion PD are acquired separately*** as the first cycle measured values DATA1-1(t) to DATA8-1(t), as the second cycle measured values DATA1-2(t) to DATA8-2(t), and as the third cycle measured values DATA1-3(t) to DATA8-3(t).

Id. ¶156.

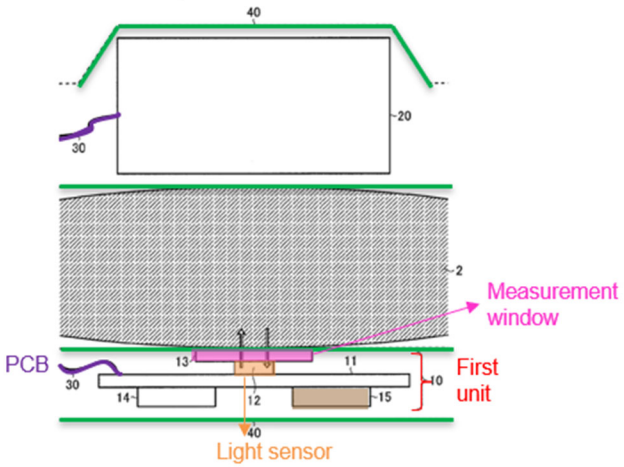
g. Element 1[d]: one or more processors configured to process the data acquired by the plurality of sensors based at least in part on a reflectance, an absorbance, or both of the received light associated with the two or more wavelengths; and

168. Niwa teaches Element 1[d].

169. As I discussed in Section V.A.5, light interacting with tissue at the microscale (wavelength scale) undergo absorption, reflection, or transmission.

170. Niwa's plethysmogram sensor includes processing circuit 15 (below, brown) which "controls [the] entire operation of the plethysmogram sensor" and acquires and processes various information about the plethysmogram of the user based on a measured value from the light receiving portion. Ex-1005 ¶212. As illustrated in Figure 27, when the user's finger is pressed to the measurement window (pink) and the light emitting and light receiving portions are provided at the same side against the finger, the LED's light is emitted with an intensity to penetrate through the finger's tissue and the reflected light is detected by the light receiving portion. *Id*. ¶¶117, 209. This construction is called a "reflection type" and allows the light receiving portion to detect the amount of light absorbed by the user's peripheral arterial to acquire the value of the absorption coefficient. *Id*. ¶209. As I discussed in Section V.A.5, in reflection mode, light from the LEDs penetrates the tissue and scatters through the tissue back to the same side of the tissue as where the LED is placed, and the light detecting portion measures the light that has traversed the tissue. The processing circuit extracts the output intensities of the light emitting portion and "adopts a sum value or an average value as the pulse intensity." *Id*. ¶46.

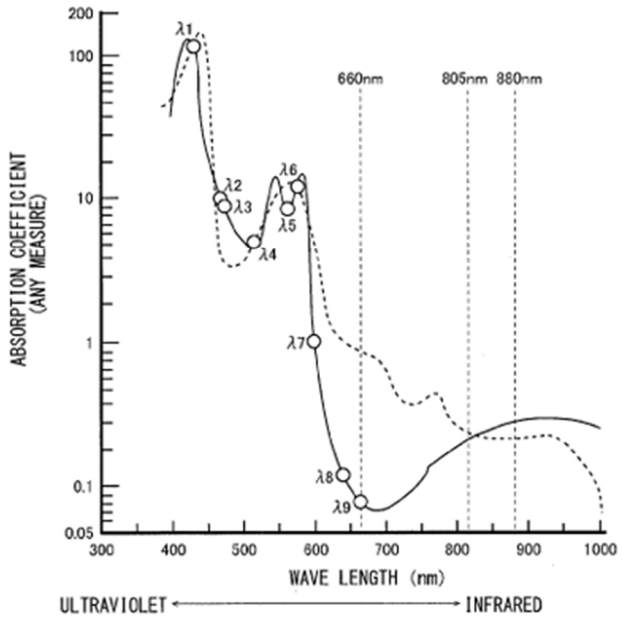
FIG.27



Id., Fig. 27.

171. As shown in Figure 18, there is relationship between the wavelength of the light from the LEDs and the absorption coefficient of oxyhemoglobin HbO2. Ex-1005 ¶169. As I discussed in Section V.A.3, the absorption coefficient "characterizes the average number of absorption events per unit path length of photons traveling in the tissue." The absorption coefficient can also be calculated as a function of wavelength. Niwa explains that it is easier to use "the visible light region whose wave length is shorter than or equal to 600 nm as the output wave length of the light emitting portion." *Id.* ¶170.

FIG.18



Id., Fig. 18.

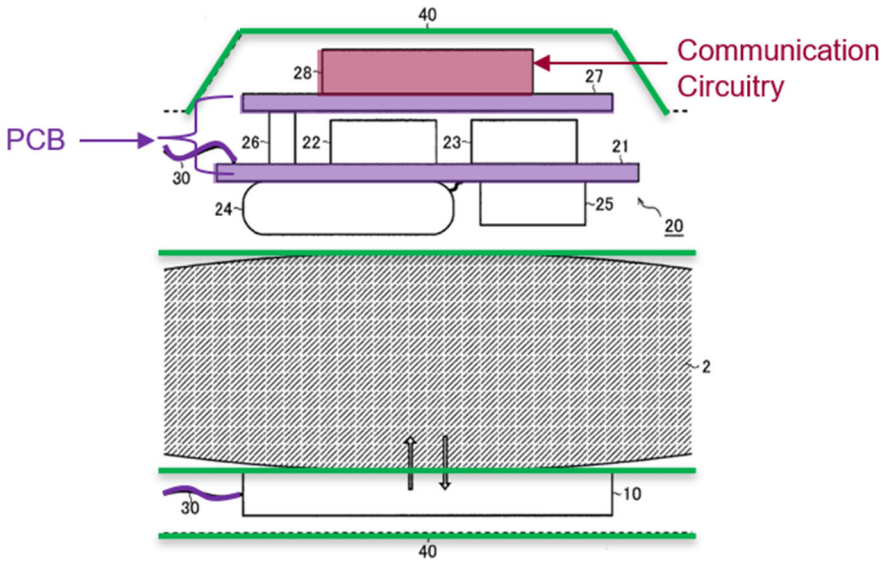
h. Element 1[e]: a communication module communicatively coupled with the plurality of sensors, the one or more processors, or both, the communication module configured to transmit the data acquired by the plurality of sensors, an analysis of the data generated by the one or more processors, or both, to a user device.

172. Niwa teaches Element 1[e].

173. Niwa's finger ring housing has wireless communication circuit 28 in second unit 20 that "transmits the measurement data acquired at the first unit 10" such as "the raw data provided from the amplifier circuit 14, the processed data

various processes has performed at the processing circuit 15, or the stored data provided from the memory 23" to an outside apparatus such as a user's personal computer or a cell phone. Ex-1005 ¶¶185, 220. The wireless communication circuit can use a "Bluetooth (the registered trademark) module IC." *Id.* As described above, cable 30 "connect[s] the first unit and the second unit electrically." *Id.* ¶62. Therefore, the communication circuitry in second unit 20 is electrically "coupled" to the plurality of sensors and processor in the first unit 10 by cable 30 to transmit the data acquired from the sensor and processed by the processing circuit 15 to an external device. *Id.*, Fig. 28.

FIG.28



2. Dependent Claims 2-5 and 11-16

a. Claim 2: The wearable computing device of claim 1,

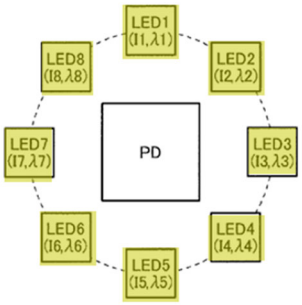
wherein the one or more light-emitting components comprise a first light-emitting component configured to emit light associated with the first wavelength, a second light-emitting component configured to emit light associated with the second wavelength, and a third light-emitting component configured to emit light associated with a third wavelength, wherein the first light-emitting component, the second light-emitting component, and the third light-emitting component are physically separated from one another.

174. Niwa teaches Claim 2.

175. As I discussed in Section VIII.A.1.e (Element 1[c(ii)]), Niwa's plethysmogram sensor has "eight light emitting portions LED1 to LED8 (i.e., a light emitting diode) equally spaced from one another and placed on a circumference with a central focus on the light receiving portion PD." Ex-1005 ¶120. Niwa explains that each LED is associated with an output wavelength denoted as ***λ1*** to ***λ8*** which "different from one another (i.e., from a visible light region to a near-infrared region)." *Id*. ¶147. Niwa also explains that "the number of the light emitting portions is simply an example" and a number other than eight can be adopted. *Id*. ¶120. In view of the non-limiting example, a POSITA would have understood that Niwa can have two or more LEDs that emit light at different wavelengths including visible light to near-infrared in order to offset noise and improve the sensor's readings and to measure multiple-blood components – e.g. glucose. Thus, a POSITA would have understood the Niwa's LEDs are configured

to have a first wavelength associated with infrared light, a second wavelength associated with visible light, and an LED associated with a third wavelength in order to gather various body information of the user. *Id*. ¶118.

FIG.3



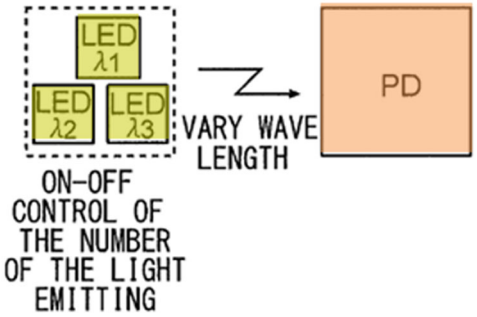
Id., Fig. 3

b. Claim 3: The wearable computing device of claim 1, wherein the one or more light-emitting components comprise a single light-emitting module configured to emit the light associated with the first wavelength, the second wavelength, and a third wavelength.

176. Niwa teaches Claim 3. As I described above in Section VIII.A.1.e (Element 1[c(ii)]), light sensor module 12 has eight LED emitters, emitting light of eight different wavelengths. Niwa also explains that "the number of the light emitting portions is simply an example" and a number other than eight can be adopted. Ex-1005 ¶120. Moreover, Figure 16B, Niwa illustrates a "single light emitting portion" associated with several light emitting elements (LEDs) with

different output wavelengths. *Id*. ¶167.

FIG.16B



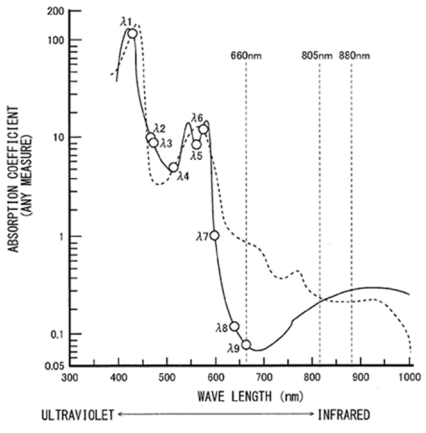
Id., Fig. 16B.

c. Claim 4: The wearable computing device of claim 1, wherein the one or more processors are further configured to: determine a first absorbance of the first wavelength, and a second absorbance associated with the second wavelength; and determine one or more characteristics of blood of the user based at least in part on the first absorbance and the second absorbance.

177. Niwa teaches Claim 4. Niwa's processor determines an absorbance of the first and second wavelengths. As I discussed in Section VIII.A.1.g (Element 1[d]), Niwa's plethysmogram sensor includes processing circuit 15 that acquires and processes various information about the plethysmogram sensor, such as the absorption coefficient. Ex-1005 ¶¶169, 212. As I discussed above in Section V.A.3, a POSITA would have understood that the absorption coefficient describes how far a particular wavelength of light can penetrate through the body before it is

absorbed. *See* Ex-1041, 0002. As shown in Figure 18, a POSITA would have understood that Niwa's first wavelength ***λ1*** is associated with a first absorbance coefficient (e.g., 100) and Niwa's second wavelength ***λ2*** is associated with a second absorbance coefficient (e.g., 10).

FIG.18



178. *Id*., Fig. 18. Based on the absorbance of the first or second wavelengths, Niwa's determines a characteristic of the user's blood. Specifically, the solid line of Niwa's Figure 18 illustrates the relationship between the "LED wave length and the absorption coefficient" of oxyhemoglobin (HbO2) detected by the plethysmogram sensor. Ex-1005 ¶169. Based on the oxyhemoglobin absorption coefficients, "the oxygen saturation of the arterial blood" of the user can be determined. *Id*. ¶¶170, 190. As the next claim demonstrates, oxygen saturation (oxygenation) is a characteristic of the blood.

d. Claim 5: The wearable computing device of claim 4,

wherein the one or more characteristics of the blood of the user comprise a blood alcohol level, a blood glucose level, a blood oxygenation level, or any combination thereof.

179. Niwa teaches Claim 5. As I discussed in the previous section and Section V.A.3, the absorbance coefficients are used to determine a characteristic of the blood's oxygenation level: "pulse oxymeter to detect the oxygen saturation of the arterial blood." Ex-1005 ¶170.

e. Claim 11: The wearable computing device of claim 1, wherein the wearable computing device comprises a finger-worn wearable ring device, wherein the one or more light-emitting components comprise a first light-emitting component positioned within the housing of the finger-worn wearable ring device at a first radial position, and a second light-emitting component positioned within the housing of the finger-worn wearable ring device at a second radial position different from the first radial position.

180. Niwa teaches Claim 11. Niwa's plethysmogram sensor is a "finger ring" "worn on the third joint of the finger 2." Ex-1005 ¶191. As I discussed Sections VIII.A.1.e-f (Element 1[c(ii)] and 1[c(iii)]), Niwa's finger ring housing has a light emitting portion with eight light emitting components (LED1 to LED8) centrally focused around the light receiving portion PD as shown in Figure 3. *Id*. ¶120, Fig. 3.

181. Niwa's light sensor 12 (the claimed light emitting component) has various light emitting components at different radial positions because Niwa

describes Figure 3 as the "Layout of the Light Emitting Portion and the Light Receiving Portion" of the first unit's light sensor 12. Ex-1005 ¶120. As shown below in Figure 27 and Figure 3, the first unit 10 which houses the light sensor 12 (annotated), faces the user's skin (finger 2). *Id.* ¶¶50, 200. Light sensor 12, which is part of first unit 10, "can be located at the vicinity of the finger 2 as much as possible" to improve measurement accuracy. *Id*. ¶208.

182. A POSITA would have understood that the light sensor (or any PPG sensor) would be placed tangentially or flushed against the user's finger. As I describe above in Section V.A.1, PPG uses a light source and photodetector at the skin's surface to take a measurement. *See* Ex-1038 (Castaneda); *see also* Ex-1006 (Yuen), 12:24-42 ("little to no gap between the skin side of the device and the juxtaposed surface of the skin of the user"). For example, Yuen explains that "a more secure physical connection between the user's skin and the optical window … improves sustained and/or fixed contact between the biometric monitoring device and the user's skin … which may reduce the amount of stray light measured by the photodetector, decrease motion between the biometric monitoring device and the user… all of which may increase the quality of the cardiac signal." Ex-1006 (Yuen), 13:46-62. Thus, a POSITA would have understood that the sensor would benefit from being placed tangentially or flush against the finger.

FIG.27

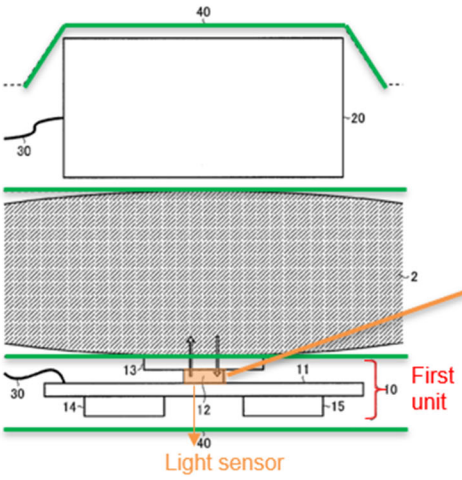
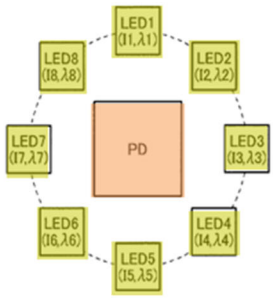


FIG.3



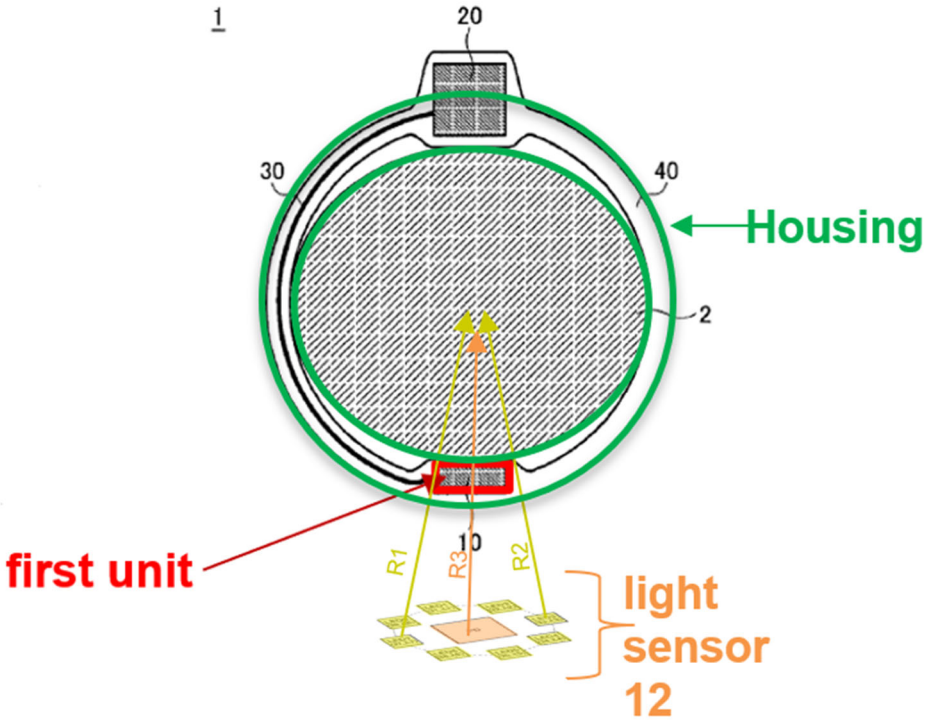
183. *Id*., Fig. 3. Modified Figure 22′ below superimposes the light emitting components and photodetector of Figure 3 in the light emitting portion first unit 10's light sensor 12. As annotated in modified Figure 22′, Niwa's LED7 (yellow) is positioned at a first radial position (R1) and LED3 (yellow) is positioned at a second radial position (R2) within the housing of the sensor (green). A POSITA would have understood LED7 and LED3 are positioned at different radial positions because the LEDs are located at different circumferential positions along the curve of the ring, (i.e., the claimed "radial position"), just like the '179 Patent. Ex-1001, Figs. 3B, 3C. A POSITA would have also understood that other LEDs in this specific orientation or variations would be in different radial positions. Further, a POSITA would have been motivated to have the LEDs would be at different radial positions because separation between the LEDs is important to enhance the quality

of the plethysmogram signal and for redundancy within the device.

184. If PO argues that the LEDs in Niwa's Figure 3 are oriented in a plane that is parallel to the plane of the ring, then (while this orientation would be illogical because the emitters would emit light into the ambient environment rather than the skin) it would still result in a number of LEDs being at different radial positions relative to the center of the ring.

185. As I discussed in Section V.A.7, separation between the LEDs and the light receiving portion is important for signal quality. Placing the LEDs at different radial positions can result in beneficial redundancies and for multiple illumination pathways through the tissue and provide for stronger signals that relate to the heart characteristics of the user. For example, U.S. Patent No. 7,468,036 to Rulkov et al. ("Rulkov") recommends a "greenlight LED and a pulsed infrared LED to offset noise affects of ambient light and sunlight." Ex-1039, 6:56-58.

186. As explained above, the LEDs are arranged to emit different wavelengths. *See* Section VIII.A.1.e (Element 1[c(ii)]). Thus, a POSITA would have understood to have an LED that emits infrared light be positioned at a different radial position than an LED that emits visible light in order to capture different segments of tissues or for redundancy.



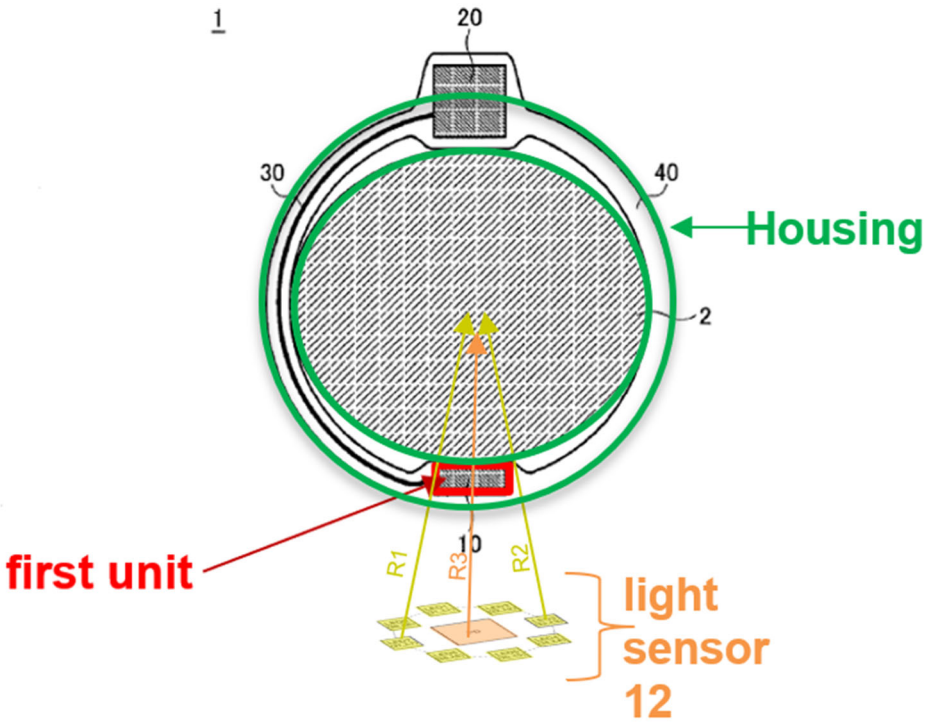
Id., Fig. 22′.

f. Claim 12: The wearable computing device of claim 11, wherein at least one light-receiving component is positioned within the housing at a third radial position that is between the first radial position and the second radial position.

187. Niwa teaches Claim 12. Niwa's light-receiving component is positioned within the housing at a third radial position that is between the first radial position and the second radial position. Niwa discloses "multiple light emitting portions provided at different places [and] at least a single light receiving portion to detect each intensity of lights emitted from each of the multiple light emitting portions." Ex-1005 ¶32; see also *id.* ¶¶43, 117, Fig. 1. As shown in

modified Figure 22′, Niwa's light receiving portion PD (orange) is positioned at a third radial position (R3) that is between the first radial position (R1) of LED7 (yellow) and second radial position (R2) of LED3 (yellow) within the housing of the sensor (green).

188. As I discussed in Section V.A.7, separation between the LEDs and the light receiving portion is important for signal strength and quality. Placing the LEDs at different radial positions can result in beneficial redundancies and for multiple illumination pathways through the tissue and provide for stronger signals that relate to the heart characteristics of the user.



Id., Fig. 22′.

g. Claim 13: The wearable computing device of claim 1, further comprising: a power management module disposed within a cavity between the interior wall and the exterior wall, the power management module configured to wirelessly transfer energy from an external energy source to a battery of the wearable computing device through the interior wall, the exterior wall, or both.

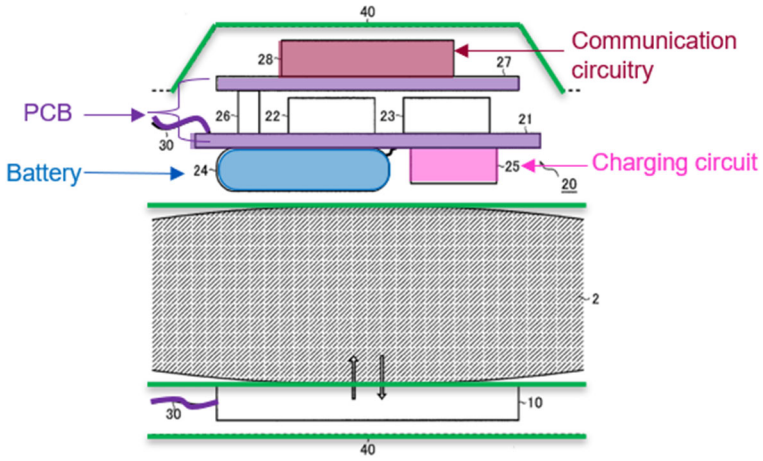
189. Niwa teaches Claim 13. Niwa has a power management module within a cavity between the interior and exterior wall. Niwa's finger ring has a "charging circuit 25" inside of second unit 20 that charges battery 24 with an outside power source supply. Ex-1005 ¶218, *see also id*. ¶221. As shown in Figure 28, a POSITA would have understood that Niwa's charging circuit 25 is disposed in a "cavity" formed between the exterior wall and interior wall because the second unit (including the charging circuit) is covered by ring housing 40 (green, comprising the external wall that is exposed to the environment and the internal wall that touches the user's finger).

190. A POSITA would have designed the ring housing in Niwa to have a cavity sized to accommodate the charging circuit and other electronic components—otherwise these components would be crushed or compressed because the solid ring and circuit components cannot simultaneously occupy the same space. As I discussed in Section V.B.2, by 2013 it was well understood that in order to house electronic components within wearable devices, there must be an

internal space like a cavity between two housing portions. For example, U.S. Patent No. 6,201,698 to Hunter teaches that "the side walls and the web together create a cavity [] to house the electronic circuit." Ex-1060, 2:56-57.

191. Niwa also describes that the exterior wall and interior wall of finger ring should be "water-proof" so that it is "possible to measure the plethysmogram without breaking down even if it is soaked [in] water (e.g., rain) or sweat." Ex-1005 ¶205. A POSITA would have understood that all the components in Niwa exist within a protected cavity inside the finger ring type housing 40, which is comprised of exterior wall and interior wall because the finger ring housing 40 "covers" and "water-proofs" the components. As I discussed in Section V.B.2, a POSITA would have understood that attaching electronics to a surface in the device and that the location of the attachment (for example, at the top or bottom of a cavity) would have been a matter of design choice.

FIG.28



192. Niwa's power management module is configured to wirelessly charge the battery through the finger ring's walls. Niwa explains that charging circuit 25 receives power by a non-contact method such as "an electromagnetic induction method, an electric field connection method, or an electric field resonance method." Ex-1005 ¶218. Niwa states that the charging circuit "performs the ***charge control of the battery 24*** according to the power source supply from outside." *Id*. Thus, a POSITA would have understood the Niwa's charging circuit is the "power management module" that wirelessly transfers energy from an outside power supply to the battery using a noncontact electromagnetic induction method.

193. As I discussed in Section V.B.5, induction charging was widely used for charging batteries in wearable electronic devices.

h. Claim 14: The wearable computing device of claim 13, wherein the power management module comprises an inductive charging component configured to transfer energy from the external energy source to the battery via an inductive charging process.

194. Niwa teaches Claim 14. As I discussed in the previous section, Niwa's charging circuit can use an electromagnetic induction method which is configured to transfer energy from a power supply outside to the battery. Ex-1005 ¶218.

195. As I explained in Section V.B.5, induction charging was widely used for charging batteries in wearable electronic devices. By 2013 wireless power transfer was used either for "real-time energy" or "to charge batteries" in biomedical devices. *See* Ex-1053, 1.

i. Claim 15: The wearable computing device of claim 1, wherein the housing comprises: an internal housing component defining the interior wall; and an external housing component defining the exterior wall, the external housing component coupled to the internal housing component, wherein one of the internal housing component or the external housing component further defines a first side wall and a second side wall that extend between the internal housing component and the external housing component.

196. Niwa teaches Claim 15. As I explained above in Section VIII.A.1.b (Element 1[a]), Niwa has a housing with interior and exterior walls. Specifically, as shown in Figure 26, Niwa's "finger ring type housing 40" has an inner portion

(green) that surrounds "the ball side of the finger 2 (i.e., palm side) when the finger ring type housing 40 is worn" for the plethysmogram measurement. Ex-1005 ¶192. A POSITA would have understood that the inner portion is the internal housing component defining an interior wall of Niwa's finger ring.

FIG.22

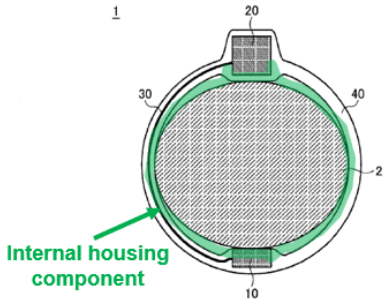
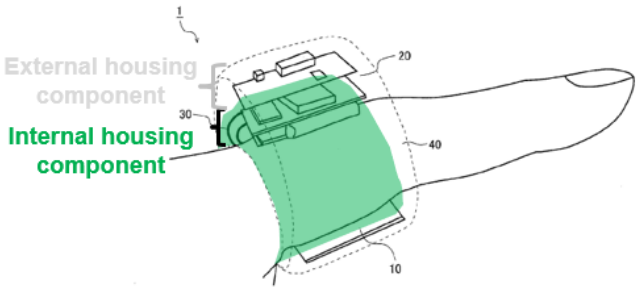


FIG.26



197. *Id*., Figs. 22, 26. Niwa's "finger ring type housing 40" also has an "external housing component" which is the outer portion of the housing that is exposed to the environment and does not touch the user's finger. As shown in annotated Figures 22 and 26, the inner portion (green) is coupled with the outer portion to form Niwa's circular "finger ring type housing 40."

FIG.22

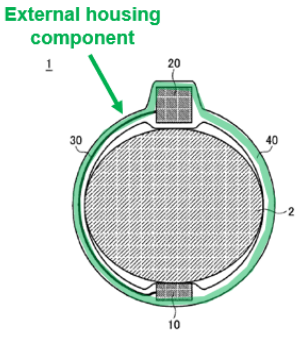
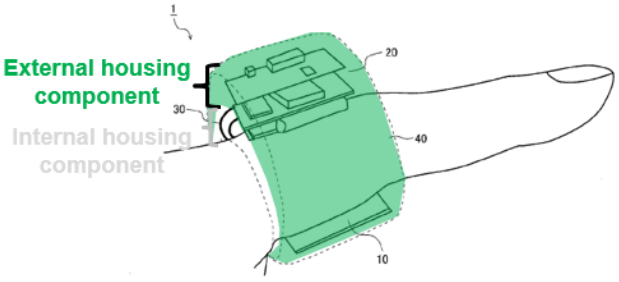
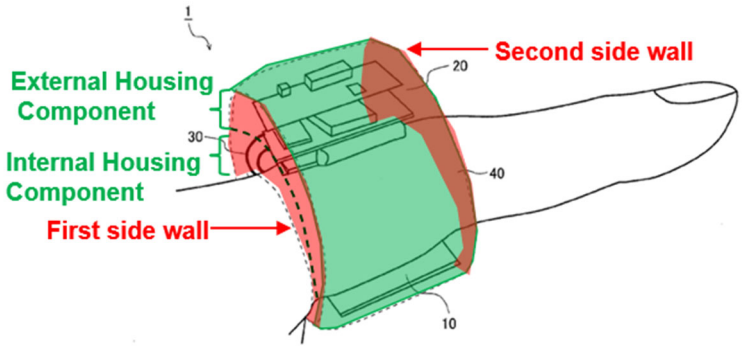


FIG.26



198. Niwa's finger ring has a first side wall and a second side wall that extend between the internal housing component and the external housing component. Niwa explains that the thickness of the finger ring type housing 40 "covers" the first unit and the second unit. Ex-1005 ¶¶200-201. Niwa also teaches that finger ring type housing has "elastic elements (e.g., silicon rubber)." *Id*. ¶204. As shown in annotated Figure 26 below, side walls (red) extend between the internal and external housing components (green) and correspond to the claimed side walls because they are the material that connects the external and internal housing components at a thickness that "covers" the first and second units inside the ring. A POSITA would have found it obvious for Niwa's side walls to be extended between the internal and external housing components to maintain the housing structure to cover the first unit and second unit of the sensor.

FIG.26



199. As I discussed in Section V.B.1 and V.B.2, wearable devices having

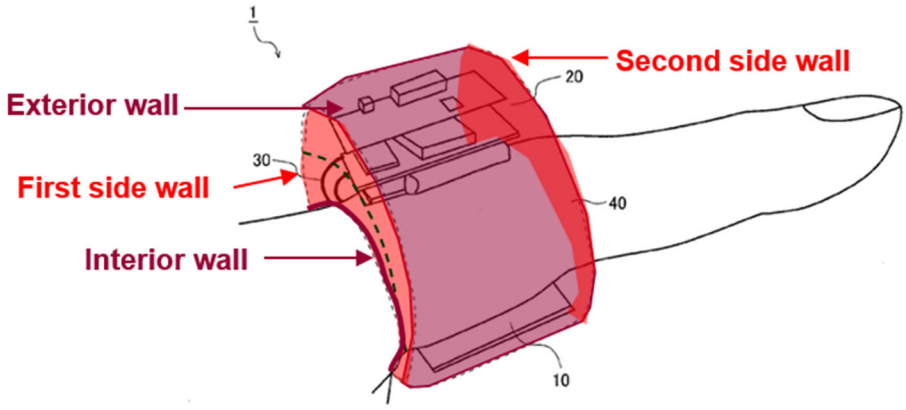
an interior and exterior component was well-known. For example, U.S. Patent No. 6,699,199 to Asada teaches that "one or more photo diodes 2 and one or more light-emitting diodes (LEDs) 4 are imbedded in a ring 10." Ex-1034, 2:59-61 (Asada '199). Moreover, U.S. Patent No. 6,745,061 to Hicks teaches that "[i]ncluded within the assembly 350 are upper and lower flexible members 304 and 300, respectively," which are "thermally bound to one another sandwiching a leadframe 308 between their inside surfaces." Ex-1025, 6:48-54. "This leadframe 308 contains active components (i.e., LEDs and a photodetector) for use in oximetry measurements." *Id*., 6:48-54. Similarly, Schröder teaches having multiple components. Schröder's ring has two halves 16 and 18 that are manufactured by casting, milling, or embossing and are "interconnected by a suitable technology, e.g., by plugging, gluing, screwing, crimping, etc." Ex-1007, 12:10-22. Schröder provides various designs for the shape of the ring halves, such as a U-shape with inlay 12 being arranged between the components 16 and 18. *Id*., 12:45-55.

j. Claim 16: The wearable computing device of claim 15, wherein the first side wall, the second side wall, or both, are substantially perpendicular to the interior wall, the exterior wall, or both.

200. Niwa teaches Claim 16. As I described above, Niwa's interior wall is the portion of the finger ring that maintains contact with the user's finger and the

exterior wall is the portion of the finger ring that is exposed to the environment and does not directly contact the user's finger. Niwa describes that these surfaces allow the finger ring to be "water-proof" so that it is "possible to measure the plethysmogram without breaking down even if it is soaked to water (e.g., rain) or sweat." Ex-1005 ¶205. As shown in Figure 26, a POSITA would have understood that Niwa's first and second side walls (red) are substantially perpendicular to the interior wall and exterior wall (dark red) in order to "cover" and "water-proof" components so that the finger ring may continue to measure the plethysmogram. A POSITA would have found it obvious for the side walls in Niwa's finger ring to be perpendicular to the interior and exterior wall in order to extend the longevity of the device and cover the components as plethysmogram sensors are "shared by many persons (e.g., when used as rental at sports gym)." Ex-1005 ¶205.

FIG.26



Id., Fig. 26.

B. Ground 2: Claims 6-10 Are Obvious Over Niwa (Ex-1005) in view of Yuen (Ex-1006)

1. A POSITA would have been motivated to combine the teachings of Niwa and Yuen, and would have had a reasonable expectation of doing so

201. A POSITA would have been motivated to combine the teachings of Niwa and Yuen ("Niwa-Yuen") and would have had a reasonable expectation of success in doing so because each relates to the same well-known technologies. Both are directed to wearable biometric sensing devices having similar structural components including, for example, a housing which includes light emitting sources and a light receiving portion disposed within the walls of the device. *See, e.g.*, Ex-1005 ¶¶191, 209; Ex-1006, 14:33-37, 6:24-31.

202. Yuen's biometric monitoring device can be worn on an appendage of the user's body, for example, on the user's "arm, wrist, leg and/or ankle." Ex-1006, 2:7-17, 12:50-52. Yuen also teaches that the device can be "worn in any number of ways including, but not limited to" a chest band, necklace, patch, bra, earring, glasses, "or toe band." Ex-1006, 24:35-40. Niwa teaches that its wearable computing device has a finger ring construction which "worn on the third joint of the finger." Ex-1005 ¶191.

203. A POSITA would have been motivated to combine the functionality of Yuen's biometric monitoring device with Niwa's finger ring construction because a POSITA would have found it beneficial to implement Yuen's device in a more compact form that is not intrusive or obtrusive and is easier for the user to remember to wear. Yuen teaches that the device housing should enable the device to be worn by the user without "measurably or appreciably impact[ing] the user's activity." Ex-1006, 23:63-67. Moreover, an exemplary structure that Yuen teaches for its device is a "toe band," which a POSITA would have understood is structurally equivalent and/or identical to a "finger ring." Niwa teaches that a finger ring is desirable because the finger ring construction allows the plethysmogram to be measured which is worn on the third joint of the finger. Ex-1005 ¶191. Thus, design incentives and market forces would have motivated a POSITA to apply the teachings of Niwa to Yuen.

204. Niwa's wearable plethysmogram sensor "includes a single light receiving portion PD (i.e., a photo diode or a photo transistor) and [up to] eight light emitting portions LED1 to LED8 (i.e., a light emitting diode) equally spaced from one another." Ex-1005 ¶120. Niwa explains that the LEDs are "placed on a circumference with a central focus on the light receiving portion PD." *Id*. Yuen similarly explains a wearable computing device that has an optical sensor which includes "a light source [that] emits light upon the skin of the user" and "light detector [that] samples, acquires and/or detects a response or scattered/reflected light from the skin." Ex-1006, 10:8-11. Yuen's optical sensor "may obtain data related to the ambient light conditions of the environment." *Id*., 10:5-6. Moreover, Yuen's light detector "may incorporate a transimpedance amplifier stage with variable gain" to "avoid or minimize saturation from bright ambient light and/or bright emitted light from the light source." *Id*., 10:5-6, 16:56-60.

205. A POSITA would have been motivated to combine Niwa with Yuen because Yuen offers additional benefits of having a light receiving component that obtains data related to the ambient light conditions of the environment and selectively adjusts one or more operational parameters of the one or more light-emitting components based at least in part on the ambient light level.

206. Additionally, Yuen's biometric monitoring device also provides real time feedback to the user in multiple ways. For example, Yuen's biometric

monitoring device gives "real-time feedback of heart rate, heart rate variability, and/or stress to the user" and displays this data on a secondary device. Ex-1006, 26:48-49. Yuen's biometric device may also convey information to a user through "the use of audio tones, voice, songs, or other sounds." *Id*., 25:44-45. A POSITA would have been motivated to include the real time feedback for the healthcare benefits such as inviting the user to use relaxation exercises, assessing the spread of a particular disease, or notifying the user of their calorie intake to maintain or achieve a goal weight. *Id*., 29:57-30:54. A POSITA would have been motivated to combine Niwa with Yuen's benefit of providing the user with real time feedback and would have had a reasonable expectation of success of doing so.

2. Dependent Claims 6-10

a. Claim 6: The wearable computing device of claim 1, wherein the one or more processors are configured to: determine an ambient light level based at the one or more light-receiving components; and selectively adjust one or more operational parameters of the one or more light-emitting components based at least in part on the ambient light level, wherein processing the data is based at least in part on selectively adjusting the one or more operational parameters.

207. Niwa in view of Yuen teaches Claim 6. As I discussed in Section VIII.A.1.g (Element 1[d]), Niwa's processing circuit 15 is the claimed processor that "controls [the] entire operation of the plethysmogram sensor 1." Ex-1005 ¶212. Specifically, Niwa's processor receives data based on the detected visible

light to determine "the oxygen saturation of the arterial blood" because it is easier use "the visible light region." *Id*. ¶170.

208. A POSITA would have been motivated for Niwa's processor to "determine an ambient light level based at the one or more light-receiving components" because it was well-known, as taught in Yuen and as discussed in Section V.D. Yuen's biometric monitoring device determines ambient light level in order to control or adjust screen backlighting. Ex-1006, 29:57-30:54. Specifically, Yuen's biometric monitoring device has a processor with applications that "utilize sensor data" from "physiological, environmental and/or activity sensors." *Id*., 22:62-66. Yuen's physiological sensor includes "a light source [that] emits light upon the skin of the user and, in response, a light detector samples, acquires and/or detects a response or scattered/reflected light from the skin." *Id*., 10:8-11. The light detector further "obtain[s] data related to the ambient light conditions of the environment." *Id*., 10:5-6.

209. Yuen's processor further selectively adjusts one or more operational parameters of the one or more light-emitting components based at least in part on the ambient light level. Yuen's "light detector module may incorporate a transimpedance amplifier stage with variable gain" to "avoid or minimize saturation from bright ambient light and/or bright emitted light from the light source." Ex-1006, 16:56-60. For example, the light detector module amplifier

modulates the intensity of the light source and "demodulat[es] the output of the light detector" when there is "no optical shielding from ambient light." *Id*., 16:64-67. Further, if the ambient light is bright enough to obtain a heart rate signal, the light source may be reduced in brightness or turned off. *Id*., 17:1-4.

210. A POSITA would have been motivated to determine an ambient light level and selectively adjust an operation parameter based thereon, into Niwa's wearable computing device, in order to adjust the light emission from Niwa's light sensor for more efficient and accurate plethysmogram reading in view of the ambient light conditions. A POSITA would have been motivated to integrate a mechanism for determining ambient light levels and selectively adjusting operational parameters based on those levels into Niwa's wearable computing device. This integration would serve multiple purposes. For example, this integration will allow adjustments for accurate plethysmogram reading. By assessing the ambient light conditions, the device can dynamically adjust the light emission from Niwa's light sensor. This adjustment ensures that the sensor operates optimally under varying environmental lighting conditions, leading to more efficient and accurate plethysmogram readings. For instance, in high ambient light conditions, the device could increase light emission to ensure the sensor's readings are not affected by external light interference. Further, in low ambient light conditions, the device could reduce light emission. Lowering light

emission in such scenarios would help conserve power, thereby extending the battery life and reducing the frequency of required recharges. This power efficiency is particularly beneficial for wearable devices, which are often used for extended periods and rely on battery power.

b. Claim 7: The wearable computing device of claim 6, wherein the one or more operational parameters comprise an intensity of the light emitted by the one or more light-emitting components.

211. Niwa in view of Yuen teaches Claim 7. As I discussed in the previous section (Claim 6), Yuen's biometric monitoring device specifically adjusts the intensity of the light source. Yuen's "light detector module may incorporate a transimpedance amplifier stage with variable gain" to "avoid or minimize saturation from bright ambient light and/or bright emitted light from the light source." Ex-1006, 16:56-60. For example, the light detector module amplifier modulates the intensity of the light source and "demodulat[es] the output of the light detector" when there is "no optical shielding from ambient light." *Id*., 16:64-67. Further, if the ambient light is bright enough to obtain a heart rate signal, the light source may be reduced in brightness or turned off. *Id*., 17:1-4.

c. Claim 8: The wearable computing device of claim 1, wherein the one or more processors are configured to: determine whether or not the user is wearing the wearable computing device based at least in part on the data acquired by the plurality of sensors; and selectively adjust one or more operational parameters

of the plurality of sensors based at least in part on whether or not the user is wearing the wearable computing device.

212. Niwa in view of Yuen teaches Claim 8. As I discussed in Section VIII.A.1.g (Element 1[d]), Niwa's processing circuit 15 is the claimed processor that "controls [the] entire operation of the plethysmogram sensor 1." Ex-1005 ¶212. Specifically, Niwa's processor receives data based on the detected visible light to determine information about the user. *See, e.g.*, ¶170. A POSITA would have understood that Niwa's processor would determine whether the user is wearing the finger ring based on the lack of signal or data received by the sensors.

213. A POSITA would have been motivated to determine whether the user is wearing the wearable computing device based on the data acquired by the plurality of sensors in Niwa, because it was well-known, as taught in Yuen. Yuen's biometric monitoring device "may automatically detect or determine whether it is or is not attached to, disposed on and/or being worn by the user." Ex-1006, 9:15-17. For example, Yuen explains that "if at a given light intensity setting, one or more light detectors provides a low return signal, the biometric monitoring device may interpret the data is indicative of the device not being worn." *Id*., 9:27-30.

214. Based on the data returned indicating that the user is not wearing the monitoring device, Yuen's processors selectively adjusts an operational parameter

of the plurality of sensors. Specifically, upon such a determination, Yuen reduces its power consumption by "disabling or adjusting" the "light source(s) and/or detector(s). Ex-1006, 9:30-35.

215. A POSITA would have been motivated to implement Yuen's determination of whether the user is wearing the computing device and operational parameter adjustment based on that determination, into Niwa's plethysmogram sensor in order "reduce its power consumption" and save battery life. Ex-1006, 9:30-35.

d. Claim 9: The wearable computing device of claim 1, further comprising: a feedback component communicatively coupled with the one or more processors, wherein the feedback component is configured to provide feedback to the user based at least in part on the data acquired by the plurality of sensors.

Claim 10: The wearable computing device of claim 9, wherein the feedback comprises visual feedback, audible feedback, haptic feedback, or any combination thereof.

216. Niwa in view of Yuen teaches Claims 9 and 10. Niwa teaches a feedback component communicatively coupled to the processor to provide the user visual feedback. Niwa teaches using an outside apparatus for displaying "a graph of the plethysmogram data,… a numeric number, or much more data analysis." Ex-1005 ¶185. Moreover, Yuen further teaches a secondary device to display "real-time feedback of heart rate, heart rate variability, and/or stress to the user"

based on the information from the biometric monitoring device that the user is wearing. Ex-1006, 26:48-49. Yuen's biometric monitoring device also conveys sensed data directly to the user through "audio tones, voice, songs, or other sounds." *Id*., 25:44-45, 25:8-16 (using LEDs to indicate user's heart rate or goal), 25:46-26:23 (examples of information indicated to the user using visual, motion, and auditory communication methods). As I discussed in Section VIII.B.1, A POSITA would have understood the benefit of including real time feedback to the user and would have had a reasonable expectation of success of combining Yuen's feedback in Niwa's finger ring.

C. Ground 3: Claims 15-16 Are Obvious Over Niwa in view of Schröder (Ex-1007)

1. A POSITA would have been motivated to combine the teachings of Niwa and Schröder, and would have had a reasonable expectation of doing so

217. A POSITA would have been motivated to apply the teachings of Schröder and Niwa ("Niwa-Schröder") and would have had a reasonable expectation of success in doing so because each relates to the same well-known technologies.

218. A POSITA would have been motivated to combine Niwa with Schröder because they are analogous art and teach improvements to the same type of devices. Both Niwa and Schröder are directed to wearable biometric sensing devices having similar structural components including, for example, inner and

outer housing components, a cavity, and electronic components (e.g., battery and PCB) within the cavity. *See, e.g.*, Ex-1007, 11:46-48 (battery), 12:26-42 (PCB), Figs. 4-10 (showing device's structure); Ex-1005 ¶¶ 67-68 (circuits and substrate), 194-95 (FPC [Flexible Printed Circuits]), 213 (battery), Figs. 22, 26-29 (showing device's structure).

219. Further, Schröder's teachings involve methods of capturing information about finger veins. This methodology specifically targets the patterns of veins within the finger. Building on this understanding, a POSITA would have recognized that Niwa teachings, which discuss the capture of pulse oximetry data, also indirectly involve capturing information about veins. As I discussed in Section V.A.4, pulse oximetry is a non-invasive method used to measure the oxygen saturation level of the blood and heart rate through photoplethysmography (PPG), a technique that detects blood volume changes in the microvascular bed of tissue. PPG technology is sensitive to changes in blood volume within tissues, which includes the venous structures targeted by Schröder's vein image. A POSITA would have understood that both Schröder's and Niwa's techniques involve data collection from veins. This understanding would indicate that advances or techniques developed in one application (like pulse oximetry) could potentially inform or enhance methodologies in the other (like vein pattern biometrics), highlighting the interconnectedness of these imaging and sensing

technologies in capturing venous information.

220. Schröder's also teaches that its finger-ring has two halves 16 and 18 that are manufactured by casting, milling, or embossing and are "interconnected by a suitable technology, e.g., by plugging, gluing, screwing, crimping, etc." Ex-1007, 12:10-22. Schröder provides various designs for the shape of the ring halves, such as a U-shape with inlay 12 being arranged between the components 16 and 18. *Id*., 12:45-55. Schröder further teaches using injection-molding to cover the electronic part and cavity with a resin or plastic to form "a ring-shaped body." Ex-1007, 14:38-49. Depending on the POSITA's design criteria, it would have been obvious to implement either arrangement in Niwa.

221. A POSITA would have been motivated to combine the design of Niwa's finger ring construction with Schroder's finger-ring structure because a POSITA would have found it beneficial to have multiple components that are "simple, fast and inexpensive to manufacture." Ex-1007, 12:15-17. Further, Schröder explains that the components can be "adapted to different dimensions and accordingly manufactured." *Id*., 12:17-20. Thus, design incentives and market forces would have motivated a POSITA to apply Schröder's teachings to Niwa.

222. A POSITA would have had a reasonable expectation of success in combining Schröder and Niwa. A POSITA would have understood that these wearable electronic devices, specifically a ring shape, are restricted by form

factors. A POSITA would have understood, therefore, that these references disclose interrelated teachings based on routine technologies that would have been amenable to various well-understood and predictable combinations to provide smaller and more comfortable wearable devices. *Id.*

2. Dependent Claims 15-16

a. Claim 15: The wearable computing device of claim 1, wherein the housing comprises: an internal housing component defining the interior wall; and an external housing component defining the exterior wall, the external housing component coupled to the internal housing component, wherein one of the internal housing component or the external housing component further defines a first side wall and a second side wall that extend between the internal housing component and the external housing component.

223. Niwa-Schröder teaches Claim 15. As I discussed in Section VIII.A.2.i (Claim 15) Niwa's finger ring construction has a housing comprising an external housing component coupled to an internal housing component that further defines a first side wall and second side wall. Niwa's housing components also includes an internal housing component that defines the interior wall and an external housing component that defines the exterior wall. *Id*.

224. A POSITA would have been motivated for Niwa's internal housing component to define the interior wall and coupled to the external housing component which defines the exterior wall, as taught in Schroder. Schröder's

finger-ring is made of coupled ring halves 16, and 18. Ex-1007, 12:43-45 (components 16, 18). Specifically, as shown in Figures 4 and 7, Schröder's finger-ring consists of an internal housing component defining an interior wall that touches the user's finger and an external housing component defining an exterior wall that is exposed to the environment. *Id*., 12:7-8.

Fig. 7

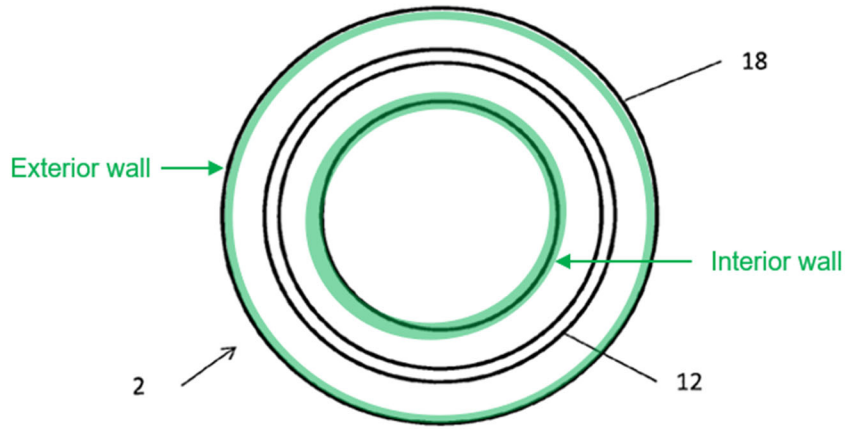


Fig. 4

Ex-1007, Figs. 4, 7.

225. A POSITA would have been motivated for the internal or external housing components in Niwa's finger ring to define a first and a second side wall

that extend between the internal and external housing components, as taught by Schröder. Schröder states that ring halves 16 and 18 are manufactured by casting, milling, or embossing and are "interconnected by a suitable technology, e.g., by plugging, gluing, screwing, crimping, etc." Ex-1007, 12:10-22. Schröder provides various designs for the shape of the ring halves, such as a U-shape with inlay 12 being arranged between the components 16 and 18. *Id.*, 12:45-55. As shown in Figure 7 below, a POSITA would have understood that the U-shaped housing components are connected to each other and thus form "side walls" (red) that extend from external housing component 18 to internal housing component 16 and surround the cavity (occupied by inlay 12). A POSITA would have understood that both housing components thus define a first side wall and a second side wall because both components are U-shaped.

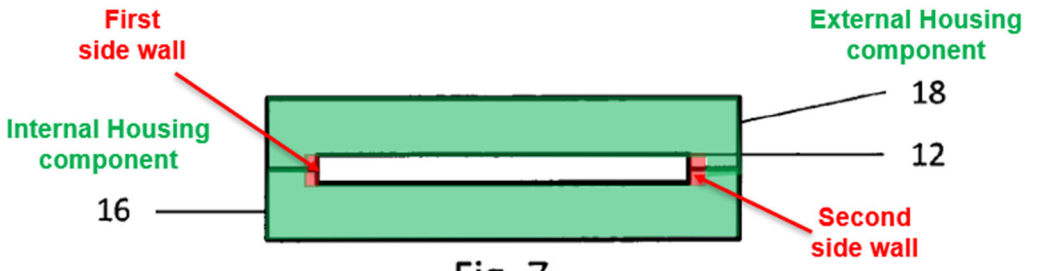


Fig. 7

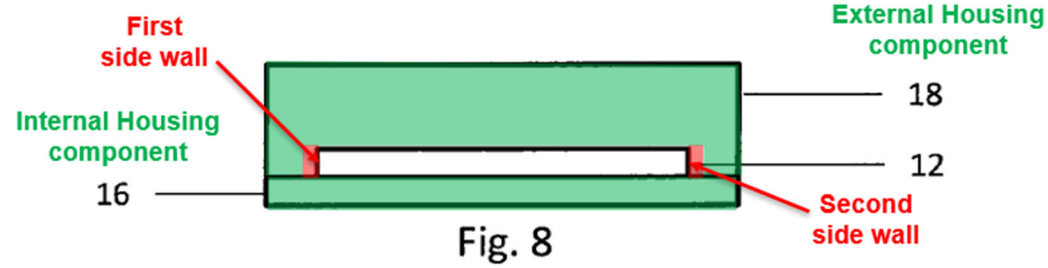


Fig. 8

226. Ex-1007, Figs. 7, 8. Similarly, in Figure 8, external housing portion 18 is a U-shape component that extends and connects to internal housing component 16 and defines the cavity by surrounding inlay 12 therefore having "side walls" (red) to form the connection. A POSITA would have understood that the external housing component defines the first and second side wall because it is U-shaped.

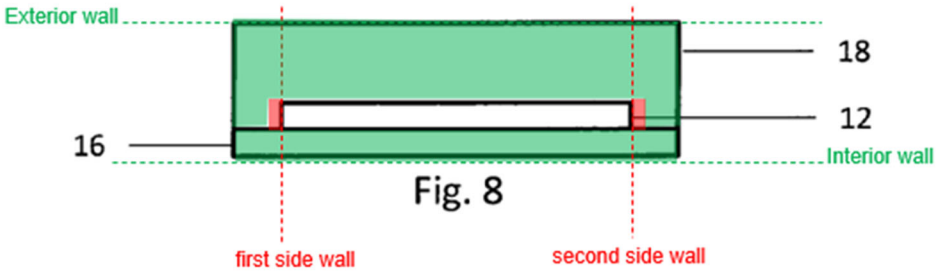
227. A POSITA would have been motivated to implement Schroder's finger ring structure with its internal and external housing components that provide side walls into Niwa's finger ring in order to improve the structure of the cavity and extend the longevity of the components by protecting Niwa's first and second units by a rigid external housing component.

b. Claim 16: The wearable computing device of claim 15, wherein the first side wall, the second side wall, or both, are substantially perpendicular to the interior wall, the exterior wall, or both.

228. Niwa-Schröder teaches Claim 16. As I discussed in Section VIII.A.1.j (Claim 16), Niwa's finger ring construction includes first and second side walls that are substantially perpendicular to the interior wall and exterior wall.

229. Further, Niwa-Schröder's first and second side walls are substantially perpendicular to the interior and exterior walls. As I stated above for Claim 15, the side walls are the part of the U-shaped components that extend from external

housing component 18 to internal housing component 16 and surround the cavity to connect the housing components. As shown in Figure 8, a POSITA would have understood that Schröder's first and second side walls (red) are substantially perpendicular to the interior and exterior wall (green) because they are portions of the U-shaped components that extend to connect the housing components.



Ex-1007, Fig. 8. As I discussed above in Section V.B.2, a POSITA would have been motivated to implement side walls that are substantially perpendicular to the interior and exterior wall to improve the structure of the cavity and extend the longevity of the components.

D. Ground 4: Claims 1-12 Are Obvious Over Yuen (Ex-1006)

1. Independent Claim 1

a. Element 1[pre]: A wearable computing device, comprising:

230. Yue teaches the preamble of Claim 1, to the extent it is limiting.

231. As shown below in Figure 2, Yuen's "portable biometric monitoring device [] may be secured to the user through the use of a band." Ex-1006, 2:7-9, Fig. 2. Yuen explains that device is configured to be worn on an appendage of the

user's body, for example, on the user's "arm, wrist, leg and/or ankle." *Id*., 12:50-52.

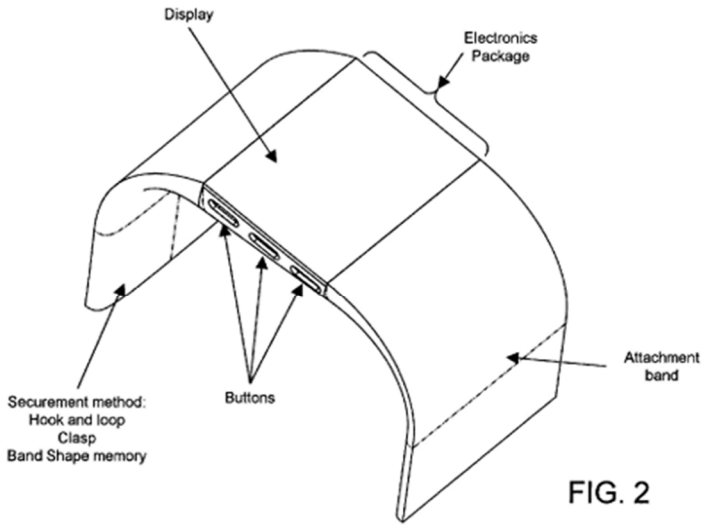


FIG. 2

b. Element 1[a]: a housing comprising an interior wall and an exterior wall of the wearable computing device

232. Yuen teaches Element 1[a].

233. Yuen teaches that its biometric monitoring device includes "two major components—a body (containing the 'electronics')" and a band that allows the device to be attached to the user. Ex-1006, 24:14-17. Yuen's Figure 2 depicts the exterior wall of the biometric monitoring device and Figure 3 depicts the interior wall of the device. *Id*., 2:7-11, Fig. 2, Fig. 3.

234. Yuen's biometric monitoring device has a housing made of "a metal material (for example, steel, stainless steel, aluminum, magnesium, or titanium)."

Ex-1006, 14:33-37. Yuen describes "an interior or skin side" as the side of the housing "whereby the surface of the device contacts, touches and/or faces the skin of the user." *Id*., 9:57-62. Yuen further teaches that a device "back made out of a metal" or plastic material provides a stiff-enough structure to maintain the device's structural integrity, while also providing "a watertight seal for the sensor package." *Id*., 14:66-15:4. Yuen describes the other side as a side or "face" that is exposed to the "ambient environment (environmental side)." *Id*., 9:64-65. A POSITA would have understood that the wall (green) exposed to the user's skin is an interior wall because it is not exposed to the environment while the outer portion of the housing exposed to the environment is the exterior wall.

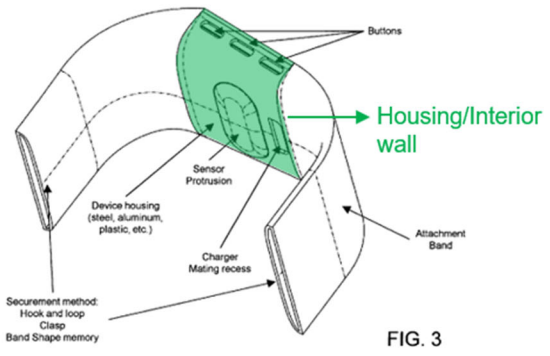


FIG. 3

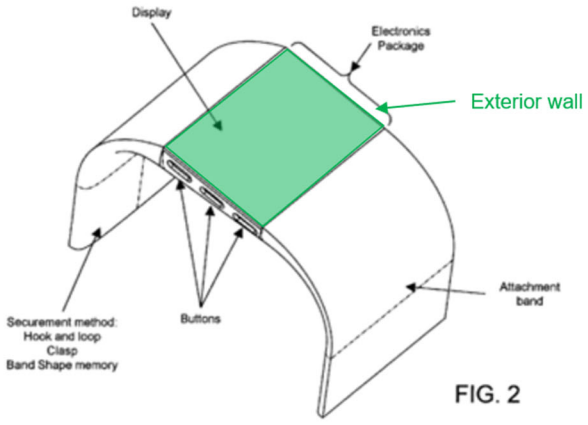


FIG. 2

Id., Figs. 2, 3.

c. Element 1[b]: a printed circuit board disposed within the housing;

235. Yuen teaches Element 1[b].

236. As shown in Figure 4, Yuen's biometric monitoring device contains a printed circuit board (purple) or "PCB" for short disposed within the housing (green) of the device.

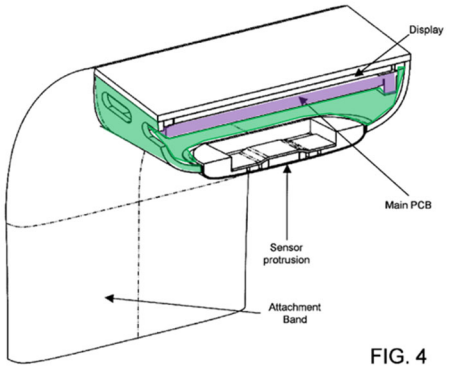


FIG. 4

Ex-1006, Figs.

237. Yuen's sensor protrusion also includes light sources and associated detectors disposed on a "flexible PCB" within the housing of the device. Ex-1006, 12:35-42, Fig. 5.

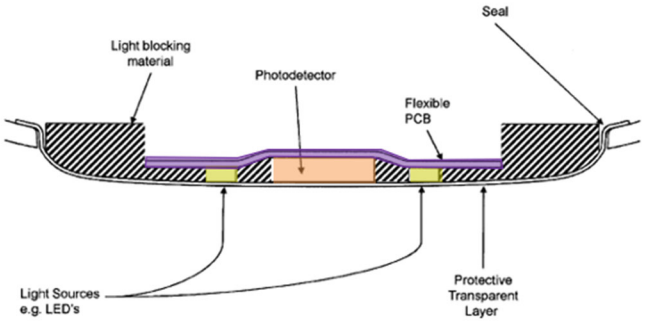


FIG. 5

d. Element 1[c(i)]: a plurality of sensors electrically coupled with the printed circuit board, the plurality of sensors configured to acquire data from a user, the plurality of sensors comprising:

238. Yuen teaches Element 1[c(i)].

239. Yuen's biometric monitoring device has a plurality of sensors electrically coupled with the printed circuit board in order to acquire user data. *Id*. As shown in Figure 5, Yuen's biometric monitoring device includes an "optical sensor having one or more light sources (LED, laser, etc.) [yellow] to emit or output light into the user's body" and "light detectors (photodiodes, phototransistors, etc.) [orange] to sample, measure and/or detect a response or reflection and provide data used to determine data which is representative of stress [], blood pressure and/or heart rate of a user." Ex-1006, 6:24-31. Yuen's light sources and photodetector are placed on a flexible PCB (purple) to enable photoplethysmography (PPG). *Id*., 12:36-38, *see also* 2:29-39. Although one photodetector is shown in Figure 5, Yuen teaches that the "the biometric monitoring device may consist of a ***plurality of photodetectors*** and photoemitters distributed along the surface of the device that touches the user's skin." *Id*., 19:3-17; *see also id*., 10:7-15.

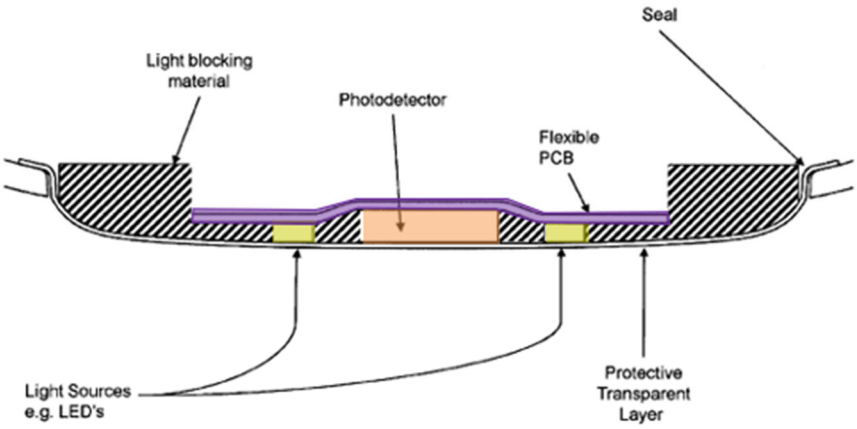


FIG. 5

Id., Fig. 5.

e. Element 1[c(ii)]: one or more light-emitting components configured to emit light associated with two or more wavelengths, wherein the two or more wavelengths include a first wavelength associated with infrared light and a second wavelength associated with visible light; and

240. Yuen teaches Element 1[c(ii)].

241. Yuen's biometric monitoring device includes "source(s) [that] may emit light having one or more wavelengths which are specific or directed to a type of physiological data to be collected" and are associated with visible and infrared light. Ex-1006, 10:22-24. For example, Yuen discusses "an LED that emits light having wavelengths corresponding to the red spectrum" and another "LED that emits light having wavelengths corresponding to the IR spectrum." Ex-1006, 10:34-39. IR is short for "infrared."

f. Element 1[c(iii)] one or more light-receiving components configured to receive the light associated with the two or more wavelengths;

242. Yuen teaches Element 1[c(iii)].

243. As shown in Figure 5, Yuen's "light detectors (photodiodes, phototransistors, etc.)" (orange) are light-receiving components that "sample, measure and/or detect one or more wavelengths" of light associated with the specific "physiological data to be collected and physiological parameter (of the user) to be assessed or determined." Ex-1006, 9:26, 10:24-42 (describing sensor configured to receive green and red light wavelengths). This teaching in Yuen refers to the embodiments shown in Figures 2-7. *Id*., 9:57-61.

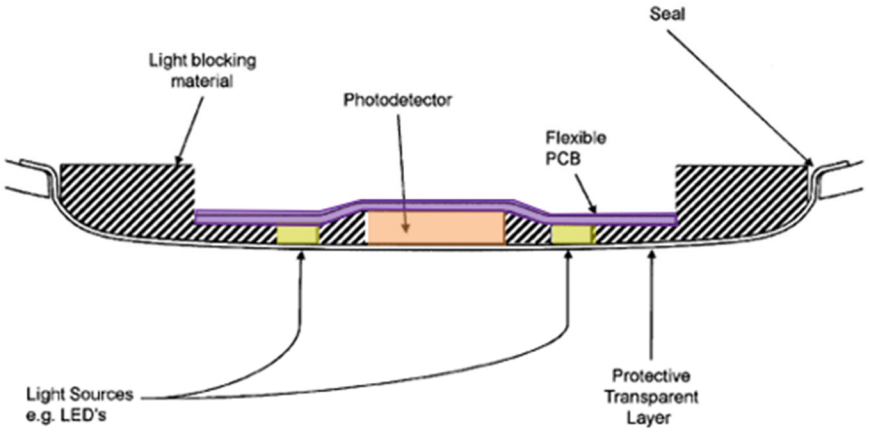


FIG. 5

Id., Fig. 5.

g. Element 1[d]: one or more processors configured to process the data acquired by the plurality of sensors based at least in part on a reflectance, an absorbance, or both of the received light associated with the two or more wavelengths; and

244. Yuen teaches Element 1[d].

245. Yuen's biometric monitoring device has a processor to process the sensor data based on the received light. *Id*. Specifically, Yuen's processor has applications that "utilize sensor data" from "physiological, environmental and/or activity sensors." Ex-1006, 22:62-66. As shown in Figure 5, Yuen's optical sensors are arranged on the device's skin side so that "a light source emits light upon the skin of the user and, in response, a light detector samples, acquires and/or detects a response or ***scattered/reflected*** light from the skin (and/or from inside the body)." Ex-1006, 10:7-12. As I discussed in Section V.A.5, in reflection mode, light from the LEDs penetrates the tissue and passes and scatters through the tissue back to the same side of the tissue as where the LEDs are placed, and the light detecting portion measures the light that has traversed through the tissue.

246. Yuen explains the sampled, acquired, or detected physiological data may then be processed or analyzed by the processing circuity. *Id*., 10:15-18, 22:60-66 ("For example, an independent application processor may be used to store and execute applications that utilize sensor data acquired and processed by ***one or more sensor processors (processor(s) that process data from***

physiological, environmental and/or activity sensors). Therefore, Yuen's processor processes data from the sensors based on the reflectance of the received light.

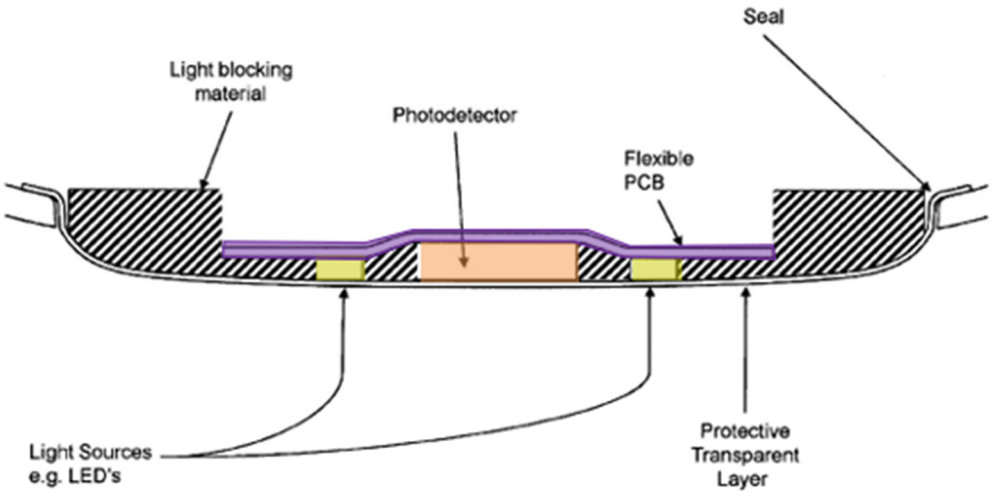


FIG. 5

Id., Fig. 5.

h. Element 1[e]: a communication module communicatively coupled with the plurality of sensors, the one or more processors, or both, the communication module configured to transmit the data acquired by the plurality of sensors, an analysis of the data generated by the one or more processors, or both, to a user device.

247. Yuen teaches Element 1[e].

248. Yuen's biometric monitoring device includes a wireless communication circuitry that displays data "via Bluetooth Low Energy in order to

give real-time feedback of heart rate, heart rate variability, and/or stress to the user." Ex-1006, 26:45-49. Yuen also teaches other communications means are available. *Id*., 27:34-59 ("ANT, WLAN, power-line networking…"). As shown in Figure 25, the communication module is communicatively coupled to the plurality of sensors and one or more processors to transmit the sensor data.

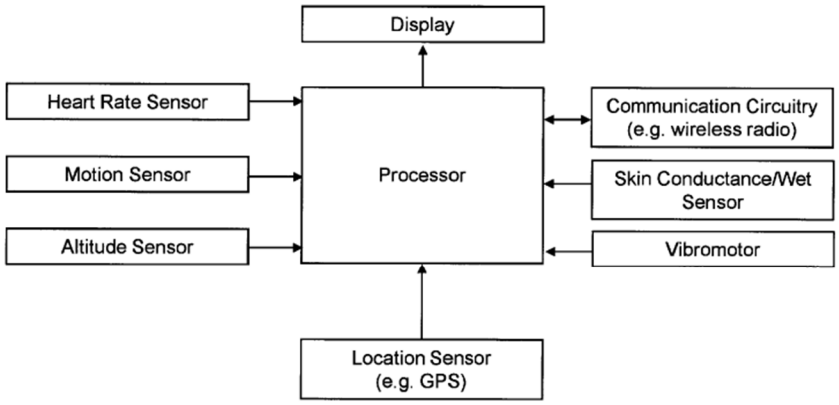


FIG. 25

Id., Fig. 25.

2. Dependent Claims 2-12

a. Claim 2: The wearable computing device of claim 1, wherein the one or more light-emitting components comprise a first light-emitting component configured to emit light associated with the first wavelength, a second light-emitting component configured to emit light associated with the second wavelength, and a third light-emitting component configured to emit light associated with a third wavelength, wherein the first light-emitting component, the second light-emitting component, and the third light-emitting component are physically separated from one another.

249. Yuen teaches Claim 2. As I discussed in Section VIII.D.1.e (Element 1[c(ii)], Yuen's biometric monitoring device includes "source(s) [that] may emit light having one or more wavelengths which are specific or directed to a type of physiological data to be collected" and are associated with visible and infrared light. Ex-1006, 10:22-24. For example, Yuen discusses three light sources separate from one another emitting different wavelengths of light: "an LED that emits light having wave lengths corresponding to the green spectrum," "an LED that emits light having wavelengths corresponding to the red spectrum," and "an LED that emits light having wavelengths corresponding to the IR spectrum." *Id*., 10:29-31, 10:34-39. Yuen also states that the device may use some or all of the sensors to acquire physiological data, including the physiological data representative of "a user's heart rate, respiration, heart rate variability, oxygen saturation (SpO2), blood volume, blood glucose, skin moisture and/or skin pigmentation level." Ex-1006, 5:32-34. Thus, a POSITA would have understood that sensors, such as the LEDs may emit light associated with one or more wavelengths at the same time, and that multiple LEDs and multiple wavelengths can be used for redundancy and improved accuracy.

250. Furthermore, as shown in Figure 11, "there may be a plurality of photodetectors and photoemitters placed along the circumference of the interior of the band." Ex-1006, 19:8-10. These may also be placed on the interior surface of

the housing in Figure 3. *Id*., 9:57-61. Thus, a POSITA would have understood that the three light emitters could have one or more wavelengths which are directed to a type of physiological data. Specifically because Yuen explains that "the color or wavelength of the light emitted by the LED (or set of LEDs) may be modified, adjusted and/or controlled" in order "to enhance the 'quality' of the physiological data obtained and/or sampled by the detector." *Id*., 10:43-50.

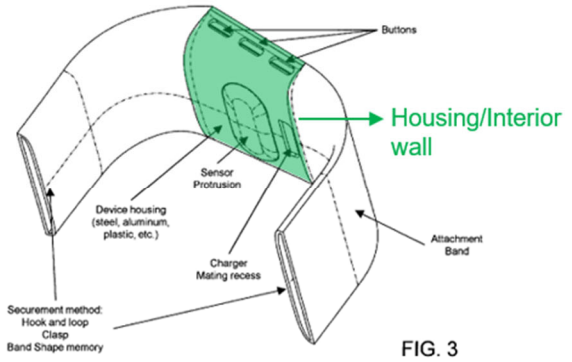


FIG. 3

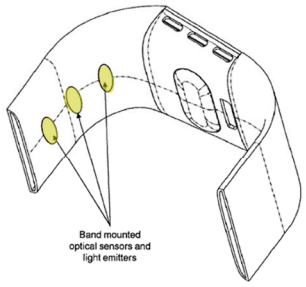


FIG. 11

Id., Figs. 3, 11.

b. Claim 3: The wearable computing device of claim 1, wherein the one or more light-emitting components comprise a single light-emitting module configured to emit the light associated with the first wavelength, the second wavelength, and a third wavelength.

251. Yuen teaches Claim 3. As I discussed in Section VIII.C.1.e (Element 1[c(ii)]), Yuen's biometric monitoring device includes "source(s) [that] may emit light having one or more wavelengths which are specific or directed to a type of physiological data to be collected" and are associated with visible and infrared light. Ex-1006, 10:22-24. Yuen further explains that the LED's color or

wavelength of the light may be modified and adjusted to enhance the quality of the physiological data. *Id*., 10:43-50. For example, the LED's color may be switched "from infrared to green when the user's skin temperature or the ambient temperature is cool in order to enhance the signal corresponding to cardiac activity." *Id*., 10:50-54. Thus, a POSITA would have understood that a single LED in Yuen may switch to emit the light associated with the first wavelength (infrared light), the second wavelength (visible colored light), and a third wavelength (another visible colored light) to enhance the quality of detected physiological data. According to Yuen, the light sensors may be arranged in a package or module. *Id*., 15:5-7. A POSITA would have recognized that the arrangement of emitters and sensors, as shown in Figure 11, could be arranged in a module or package and assembled or purchased in order to improve performance, redundancy, sensitivity to failure, or to simplify device assembly. *See* Ex-1006, Fig. 11.

c. Claim 4: The wearable computing device of claim 1, wherein the one or more processors are further configured to: determine a first absorbance of the first wavelength, and a second absorbance associated with the second wavelength; and determine one or more characteristics of blood of the user based at least in part on the first absorbance and the second absorbance.

252. Yuen teaches Claim 4. Yuen's processor determines a first and

second absorbance associated with the first and second wavelengths. As I discussed in Section VIII.D.1.e (Element 1[c(ii)]), Yuen's biometric monitoring device includes light sources that may emit light corresponding to a first and second wavelength. Yuen explains that the "light source emits light upon the skin of the user and, in response, a light detector samples, acquires and/or detects a response or scattered/reflected light from the skin." Ex-1006, 10:11. A POSITA would have understood that the amount of scattered/reflected detected by the light detector changes in response to the wavelength dependent absorbance of the illuminated tissue. The variations in detected light are representative of characteristics of blood in the vascularized tissue and other physiological data of the user.

253. For example, as I discussed in Section V.A.5, pulse oximetry devices, used to measure SpO2, are designed to operate at the macroscale or sensor scale (emitter and detector scale) and are generally described as operating in two modes: transmission mode and reflection mode. In reflection mode, light from the emitter penetrates the tissue and takes a general path that passes through the tissue back to the same side of the tissue, and the detector measures the light that has traversed the tissue. This interaction relies on the differential absorption characteristics of oxygenated and deoxygenated hemoglobin and is essential to determining oxygen saturation.

254. Yuen's processor determines a characteristic of the user's blood based on the determined absorbance(s). Yuen explains the data obtained is "processed or analyzed (for example, by resident processing circuitry)" and is "representative of, for example, a user's heart rate, respiration, heart rate variability, oxygen saturation (SpO2), blood volume, blood glucose." Ex-1006, 10:16-20. Therefore, a POSITA would have understood that Yuen determines a characteristic of the user's blood based on the absorbance of infrared or visible light (the claimed first and second wavelengths).

255. As I discussed in Section V.A.4, pulse oximetry measures peripheral arterial oxygen saturation (SpO_2) as an indicator of tissue oxygenation. Light at two different wavelengths (for example, 660 nm and 940 nm) illuminates oxygenated (oxyhemoglobin) and deoxygenated (deoxyhemoglobin) hemoglobin in blood. To calculate SpO2, the ratio of the AC to DC components of the PPG signal at two different wavelengths (typically red and infrared) is used. This ratio is indicative of the relative absorption of light by oxygenated hemoglobin (Oxy-Hb) and deoxygenated hemoglobin (Deoxy-Hb). By comparing these ratios at the two wavelengths, the proportion of Oxy-Hb to Deoxy-Hb can be determined.

256. Yuen's method involves using light emitters that emit light at these wavelengths and detectors that measure the amount of light absorbed by the blood. As I discussed in Section V.A.3, the absorbance data collected at these distinct

wavelengths provides crucial information about the blood's characteristics. Specifically, the differential absorbance at these wavelengths can be used to calculate important blood parameters such as oxygen saturation levels, glucose concentration, and other relevant biomarkers.

257. Infrared light is particularly useful for penetrating into tissues and providing data about the oxygenation levels of the blood. Hemoglobin, both oxygenated (Oxy-Hb) and deoxygenated (Deoxy-Hb), has specific absorbance properties in the infrared spectrum. By measuring the absorbance of infrared light, Yuen's device can determine the relative concentration of Oxy-Hb and Deoxy-Hb, leading to oxygen saturation readings.

258. Visible light, on the other hand, is also sensitive to variations in other blood components and can provide additional information about other blood characteristics. For instance, certain wavelengths in the visible spectrum are used to detect glucose levels and other chemical constituents in the blood.

d. Claim 5: The wearable computing device of claim 4, wherein the one or more characteristics of the blood of the user comprise a blood alcohol level, a blood glucose level, a blood oxygenation level, or any combination thereof.

259. Yuen teaches Claim 5 for the same reason I discussed in the previous section (Claim 4). Specifically, Yuen determines characteristics of the user's blood such as oxygen saturation (SpO2), blood volume, and blood glucose. Ex-

1006, 10:16-20.

e. Claim 6: The wearable computing device of claim 1, wherein the one or more processors are configured to: determine an ambient light level based at the one or more light-receiving components; and selectively adjust one or more operational parameters of the one or more light-emitting components based at least in part on the ambient light level, wherein processing the data is based at least in part on selectively adjusting the one or more operational parameters.

260. Yuen teaches Claim 6 for the same reason I discussed in Section VIII.B.2.a (Ground 2).

f. Claim 7: The wearable computing device of claim 6, wherein the one or more operational parameters comprise an intensity of the light emitted by the one or more light-emitting components.

261. Yuen teaches Claim 7 for the same reason I discussed in Section VIII.B.2.b (Ground 2).

g. Claim 8: The wearable computing device of claim 1, wherein the one or more processors are configured to: determine whether or not the user is wearing the wearable computing device based at least in part on the data acquired by the plurality of sensors; and selectively adjust one or more operational parameters of the plurality of sensors based at least in part on whether or not the user is wearing the wearable computing device.

262. Yuen teaches Claim 8 for the same reason I discussed in Section VIII.B.2.b (Ground 2).

h. Claim 9: The wearable computing device of claim 1,

further comprising: a feedback component communicatively coupled with the one or more processors, wherein the feedback component is configured to provide feedback to the user based at least in part on the data acquired by the plurality of sensors.

Claim 10: The wearable computing device of claim 9, wherein the feedback comprises visual feedback, audible feedback, haptic feedback, or any combination thereof.

263. Yuen teaches Claims 9 and 10 for the same reasons I discussed in Section VIII.B.2.d (Ground 2).

i. Claim 11: The wearable computing device of claim 1, wherein the wearable computing device comprises a finger-worn wearable ring device, wherein the one or more light-emitting components comprise a first light-emitting component positioned within the housing of the finger-worn wearable ring device at a first radial position, and a second light-emitting component positioned within the housing of the finger-worn wearable ring device at a second radial position different from the first radial position.

264. Yuen teaches Claim 11. Yuen teaches a "wearable computing device compris[ing] a finger-worn wearable ring device." Yuen describes that this device can be worn many ways on the user's body, for example, on the user's "arm, wrist, leg and/or ankle." Ex-1006, 12:50-52. Further, Yuen's device may be integrated into a "necklace, chest band, bra, patch, glasses, earring, or toe band." *Id*., 24:35-37. Because Yuen's device can be integrated into an "earring" or "toe band", a

POSITA would have found it obvious that Yuen's device could be worn as a "finger-ring" because a "toe band" and "earring" is structurally equivalent to a "finger ring." *Id*., 24:35-40. Further, Yuen teaches that "the user may touch an optical window [] with a finger on the opposing hand to initiate a heart rate measurement." *Id*., 12:65-13:1; *see also id*. 13:5-9. Thus, a POSITA would have understood that integrating the device in a finger ring would allow the optical window to already be touching the finger of the user.

265. Both fingers and toes are composed of small bones. Fingers have phalanges (three in each finger except the thumb, which has two), and toes have similar bones with three phalanges in each toe except the big toe, which, like the thumb, usually has two. The blood flow in fingers and toes is quite similar, reflecting their roles as extremities of the body. Both fingers and toes receive blood from arteries that branch off larger arteries. For fingers, the main arterial supply comes from the radial and ulnar arteries, which are branches of the brachial artery. For toes, the main supply comes from the dorsal and plantar arteries, which originate from the popliteal artery in the leg. At the level of the fingers and toes, arteries branch into smaller arterioles and then into capillaries. This extensive network of capillaries is crucial for efficient exchange.

266. As shown below in Figure 5, Yuen's "light sources [(yellow)] and photodetector [(orange)] are placed on a flexible PCB [(purple)]" within the

housing of the device. Ex-1006, 2:38-39; *see also id.*, 12:35-42.

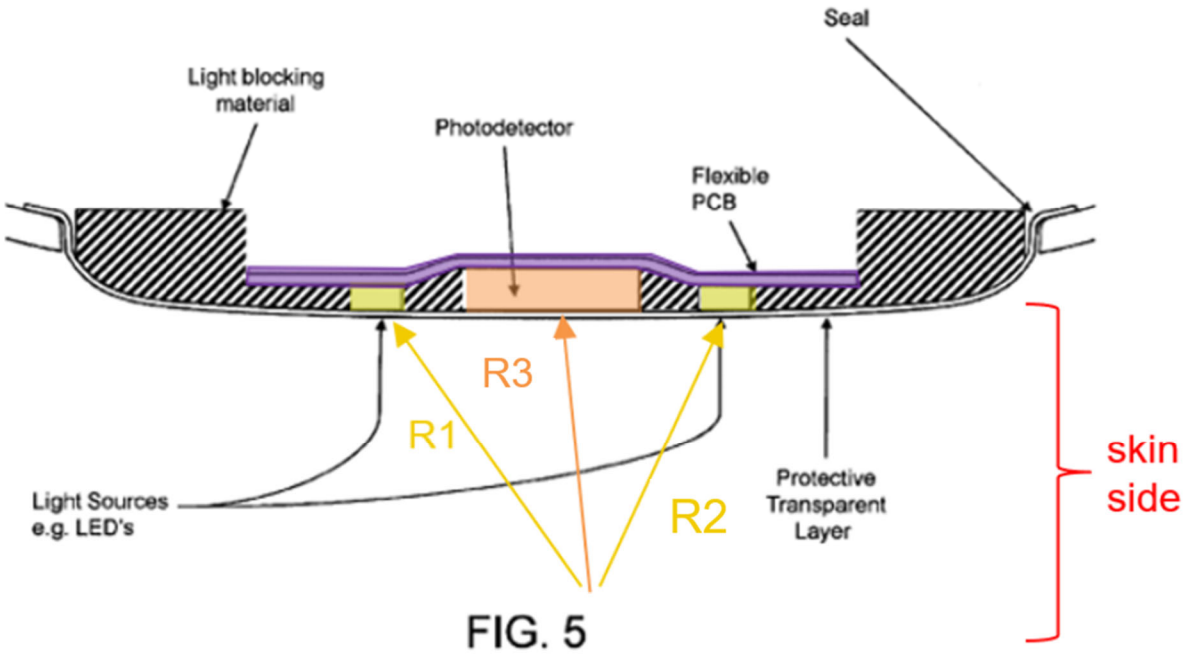


FIG. 5

Id., Fig. 5.

267. Yuen teaches a first light emitting component at a first radial position and a second light emitting component at a second radial position. Yuen explains that the "light sources (e.g. LEDs)" in Figure 5 may be "located on one or more sides of the photodetector (for example, either side or opposing sides of a photodetector) to enable photoplethysmography (PPG)." Ex-1006, 2:31-35. As shown in Figure 5 above, a POSITA would have understood that Yuen's first light source (yellow) is positioned at a first radial position (R1) and second light source is positioned at a second radial position (R2) within the housing of the device and from the center of the user's wrist, when the LEDs are placed on "either side or opposing sides of a photodetector."

268. Moreover, a POSITA would have understood that Yuen's light emitting components are positioned at two different radial positions when Yuen's biometric monitoring device is arranged as a ring because Yuen's light sources and photodetectors can adapt a circumferential and curvilinear orientation to facilitate skin contact with the user's finger. For example, Yuen explains that the light emitters and associated detectors are disposed on a "flexible or pliable substrate which facilitates the skin side of the device to conform… to the shape of the user's body part" so that there is "little to no gap between the skin side of the device and the juxtaposed surface of the skin of the user." Ex-1006, 12:24-42. Thus, the light sources disposed on the flexible PCB are conformed to contact the user's finger in the same way as the light sources in Yuen's sensor protrusion contact the user's skin in Figure 5. Therefore, a POSITA would have understood Yuen's light sources in the ring construction are positioned at different radial positions because the LEDs are located at different circumferential positions along the curve of the ring, (i.e., the claimed "radial position"), like in the '179 Patent. Ex-1001, Figs. 3B, 3C. A POSITA would have further understood that the LEDs would be at different radial positions because separation between the LEDs is important to enhance the quality of the plethysmogram signal and for redundancy within the device. Also, having the LEDs in a central circumference and away from the edges of the device, prevents light leakage from visible LEDs and interference

from ambient light.

j. Claim 12: The wearable computing device of claim 11, wherein at least one light-receiving component is positioned within the housing at a third radial position that is between the first radial position and the second radial position.

269. Yuen teaches Claim 12. As I discussed in Section VIII.D.2.i (Claim 11), A POSITA would have understood that Yuen's light sources and photodetector can be shaped to facilitate skin contact with the user's finger.

270. Yuen teaches a "light-receiving component is positioned within the housing at a third radial position that is between the first radial position and the second radial position." As shown below in Figure 5, Yuen's sensor protrusion includes light sources and photodetector disposed on a "flexible PCB" within the housing of the device at different radial positions (R1, R2, and R3). Ex-1006, 12:35-42, Fig. 5.

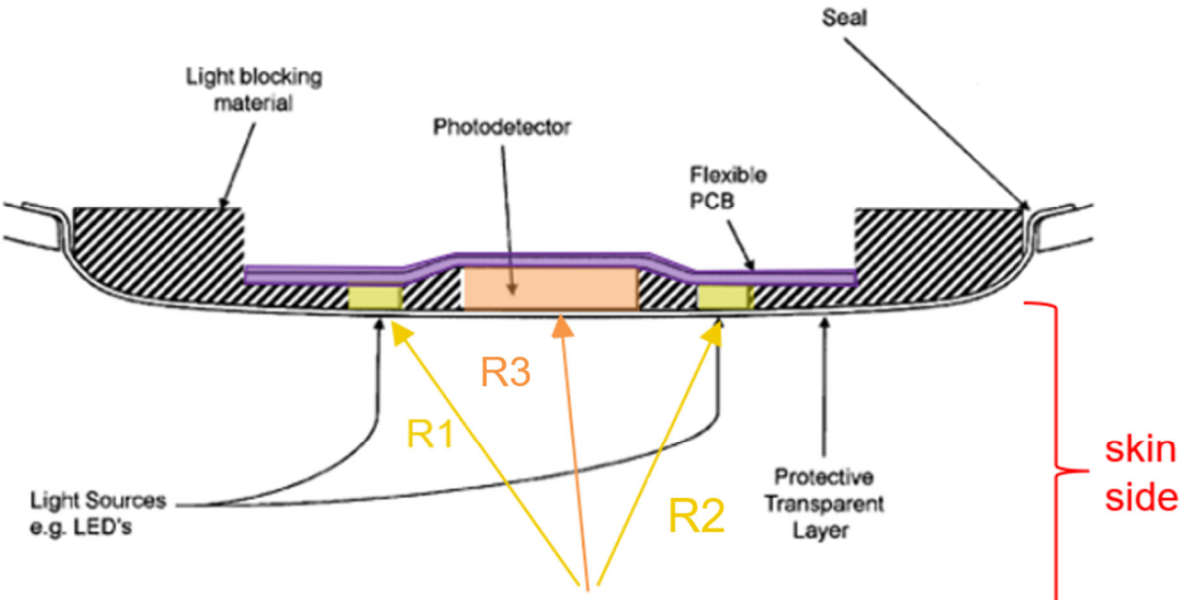


FIG. 5

271. As shown in Figure 5, Yuen's photodetector (orange) is positioned at a third radial position (R3) that is between the first and second radial position (R1, R2) of the light sources (yellow) within the housing of the device. Ex-1006, Fig. 5. As discussed above, Yuen explains that the "light sources (e.g. LEDs) may be located on one or more sides of the photodetector (for example, either side or opposing sides of a photodetector) to enable photoplethysmography (PPG)." *Id*., 2:31-35. Thus, a POSITA would have understood that photodetector is at third radial position when the LEDs are placed on "either side or opposing sides of a photodetector." *Id*.

272. Further, as I previously discussed, the light sources disposed on the flexible PCB can also conform to contact the user's finger in the same way as the

light sources in Yuen's sensor protrusion contact the user's skin in Figure 5. A POSITA would have understood that Yuen's photodetector is positioned within the housing at a third radial position that is between the first radial position and the second radial position because the photodetector is located at different circumferential position along the curve of the ring (i.e., the claimed "radial position"), like in the '179 Patent. Ex-1001, Figs. 3B, 3C. A POSITA would have further understood that the photodetector would be at different a radial position than the LEDs because separation between the LEDs and the photodetector is important to enhance the quality of the plethysmogram signal. Also, having the LEDs in a central circumference and away from the edges of the device, reduces light leakage from visible LEDs and interference to the detector from ambient light.

E. Ground 5: Claims 1-10, 13-16 Are Obvious Over Yuen (Ex-1006) in view of Schröder (Ex-1007)

1. A POSITA would have been motivated to combine Yuen's teachings with Schröder's teachings and would have had a reasonable expectation of success.

273. A POSITA would have been motivated to combine the teachings of Yuen and Schröder and would have had a reasonable expectation of success in doing so because each relates to the same well-known technologies. For example, both are directed to wearable biometric sensing devices having similar structural components including, inner and outer surfaces and an electronic component (such

as batteries and microprocessors). *See, e.g.*, Ex 1006, 12:50-52, Fig. 7; Ex 1007, 9:54-10:9, Figs. 6-10.

274. Schroder's teachings involve methods of capturing information about finger veins, which is crucial for applications such as biometric identification or medical diagnostics. This methodology specifically targets the patterns of veins within the finger.

275. Building on this understanding, a POSITA would have recognized that Yuen's teachings, which discuss the capture of pulse oximetry data, also indirectly involve capturing information about veins. As I discussed above in Section V.A.3, Pulse oximetry is a non-invasive method used to measure the oxygen saturation level of the blood and heart rate through photoplethysmography (PPG), a technique that detects blood volume changes in the microvascular bed of tissue.

276. PPG technology is sensitive to changes in blood volume within tissues, which includes the venous structures targeted by Schröder's vein image. A POSITA would understand that both Schröder's and Yuen's techniques involve data collection from veins. This understanding would indicate that advances or techniques developed in one application (like pulse oximetry) could potentially inform or enhance methodologies in the other (like vein pattern biometrics), highlighting the interconnectedness of these imaging and sensing technologies in

capturing venous information.

277. Yuen's biometric monitoring device can be worn on an appendage of the user's body, for example, on the user's "arm, wrist, leg and/or ankle." Ex-1006, 2:7-17, 12:50-52. Yuen also teaches that the device can be "worn in any number of ways including, but not limited to" a chest band, necklace, patch, bra, earring, glasses, "or toe band." Ex-1006, 24:35-40. Schröder teaches that its biometric sensing device is "a finger-ring," which "is worn by a user e.g., permanently on the finger." Ex-1007, 2:60-64, 3:61-62.

278. As I previously discussed, both fingers and toes are composed of small bones. Fingers have phalanges (three in each finger except the thumb, which has two), and toes have similar bones with three phalanges in each toe except the big toe, which, like the thumb, usually has two. The blood flow in fingers and toes is quite similar, reflecting their roles as extremities of the body. Both fingers and toes receive blood from arteries that branch off larger arteries. For fingers, the main arterial supply comes from the radial and ulnar arteries, which are branches of the brachial artery. For toes, the main supply comes from the dorsal and plantar arteries, which originate from the popliteal artery in the leg. At the level of the fingers and toes, arteries branch into smaller arterioles and then into capillaries. This extensive network of capillaries is crucial for efficient exchange.

279. A POSITA would have been motivated to combine the functionality

of Yuen's biometric monitoring device with Schröder's finger-ring structure because a POSITA would have found it beneficial to implement Yuen's device in a more compact form that is not intrusive or obtrusive and is easier for the user to remember to wear. Yuen teaches that the device housing should enable the device to be worn by the user without "measurably or appreciably impact[ing] the user's activity." Ex-1006, 23:63-67. Moreover, an exemplary structure that Yuen teaches for its device is a "toe band," which a POSITA would have understood is structurally equivalent and/or identical to a "finger ring." Schröder teaches that a finger-ring is desirable because it cannot be easily lost or taken without authorization because it is worn on the user's finger. Ex-1007, 4:15-18. Thus, design incentives and market forces would have motivated a POSITA to apply the teachings of Schröder to Yuen.

280. A POSITA would have been motivated to implement Schröder's finger-ring using Yuen because wireless charging increases a device's longevity is more convenient for users. A POSITA would have also understood that implementing Yuen's device with Schröder's finger-ring structure would ensure a tighter fit than a device worn, for example, on the user's wrist, which would reduce motion artifact, provide better shielding against ambient light, and allow for a higher quality reading from any sensors on the device (e.g., heart rate, temperature, etc.). Yuen acknowledges these motivations because it teaches the desirability for

"light source(s) and/or associated detector(s)" to be "close to the skin of the user (i.e., with little to no gap between the skin side of the device and the juxtaposed surface of the skin of the user)." Ex-1006, 12:24-35. Moreover, Yuen teaches that improving "sustained and/or fixed contact between the biometric monitoring device and the user's skin" is desirable because it "may reduce the amount of stray light measured by the photodetector, decrease motion between the biometric monitoring device and the user, and/or provide improved local pressure to the user's skin; all of which may increase the quality of the cardiac signal of interest." *Id*., 13:54-62; *see also id.*, 14:25-32 ("[T]he use of a protrusion and/or friction may improve measurement accuracy of data acquisition corresponding to certain parameters (e.g., heart rate, heart rate variability, galvanic skin response, skin temperature, skin coloration, heat flux, blood pressure, blood glucose, etc.) by reducing motions of the sensor relative to the user's skin during operation, especially whilst the user is in motion.").

281. A POSITA would also have been motivated to implement Schröder's wireless inductive charging to replace the wired connection charging in Yuen's device. A POSITA would have realized the many benefits of wireless charging, such as simplicity of use, reliability, and no need for connectors, cords, or cables.

282. A POSITA would have had a reasonable expectation of success in combining Yuen and Schröder. Yuen and Schröder are analogous prior art as they

both involve biometric sensing devices having similar structural components such as inner and outer surfaces and a cavity housing an electronic part. Moreover, a POSITA would have understood that the electronic components of Yuen and Schröder's biometric sensing devices are similar such that they are programmable using standard processors and are interchangeable regardless of whether the devices are in the form of, for example, a toe band or a finger-ring. A POSITA would have understood, therefore, that these references disclose interrelated teachings based on routine technologies that would have been amenable to various well-understood and predictable combinations to provide more features and enhance user interest.

2. Independent Claim 1

a. Element 1[pre]: A wearable computing device, comprising:

283. Yuen in view of Schröder teaches Element 1[pre] for the same reasons I discussed in Section VIII.D.1.a (Ground 4).

b. Element 1[a]: a housing comprising an interior wall and an exterior wall of the wearable computing device

284. Yuen in view of Schröder teaches Element 1[a] for the same reasons I discussed in Section VIII.D.1.b (Ground 4).

285. Further, as shown in Figures 4 and 8, Schröder's finger-ring consists of an interior wall and an exterior wall. Ex-1007, 12:7-8. A POSITA would have

understood that the interior wall is the wall touching the finger of the user and the exterior wall is exposed to the environment.

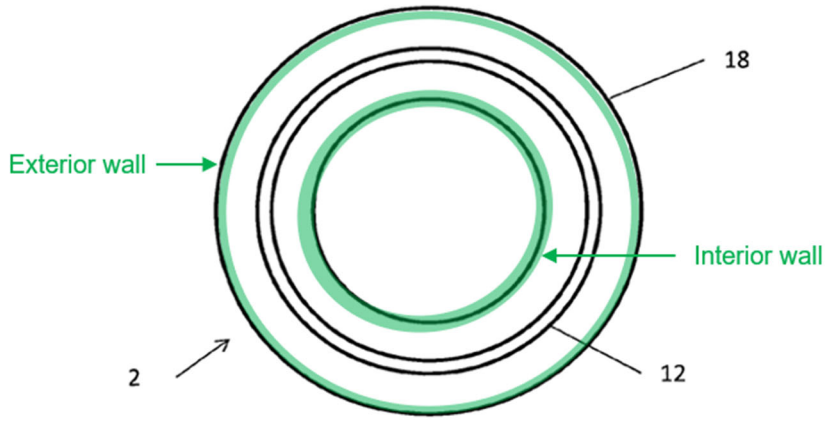


Fig. 4

Fig. 8

Ex-1007, Figs. 4, 8.

286. A POSITA would have clearly understood that the wall encircling finger constitutes the interior wall of the device, which is primarily oriented towards and in contact with the body part it surrounds. This interior wall serves crucial functional roles, including maintaining the correct positioning of the device on the finger and protecting the internal components from direct contact with the

skin. Similarly, a POSITA would have clearly understood that the wall that is exposed to the environment, the outward facing surface of component 18, is the exterior wall. This exterior wall is crucial for shielding the device from external elements and physical impacts, ensuring durability of the device. A POSITA would recognize that this exterior wall also potentially interacts with environmental experiencing variable conditions such as temperature, humidity, and mechanical stress, necessitating robust materials and design considerations to maintain the device's integrity and performance over time.

c. Element 1[b]: a printed circuit board disposed within the housing;

287. Yuen in view of Schröder teaches Element 1[b] for the same reasons I discussed in Section VIII.D.1.c (Ground 4).

d. Element 1[c(i)]: a plurality of sensors electrically coupled with the printed circuit board, the plurality of sensors configured to acquire data from a user, the plurality of sensors comprising:

288. Yuen in view of Schröder teaches Element 1[c(i)] for the same reasons I discussed in Section VIII.D.1.d (Ground 4).

e. Element 1[c(ii)]: one or more light-emitting components configured to emit light associated with two or more wavelengths, wherein the two or more wavelengths include a first wavelength associated with infrared light and a second wavelength associated with visible light; and

289. Yuen in view of Schröder teaches Element 1[c(ii)] for the same

reasons I discussed in Section VIII.D.1.e (Ground 4).

f. Element 1[c(iii)] one or more light-receiving components configured to receive the light associated with the two or more wavelengths;

290. Yuen in view of Schröder teaches Element 1[c(iii)] for the same reasons I discussed in Section VIII.D.1.f (Ground 4).

g. Element 1[d]: one or more processors configured to process the data acquired by the plurality of sensors based at least in part on a reflectance, an absorbance, or both of the received light associated with the two or more wavelengths; and

291. Yuen in view of Schröder teaches Element 1[d] for the same reasons discussed in Section VIII.D.1.g (Ground 4).

h. Element 1[e]: a communication module communicatively coupled with the plurality of sensors, the one or more processors, or both, the communication module configured to transmit the data acquired by the plurality of sensors, an analysis of the data generated by the one or more processors, or both, to a user device.

292. Yuen in view of Schröder teaches Element 1[e] for the same reasons I discussed in Section VIII.D.1.h (Ground 4).

3. Dependent Claims 2-10, 13-16

a. Claim 2: The wearable computing device of claim 1, wherein the one or more light-emitting components comprise a first light-emitting component configured to emit light associated with the first wavelength, a second light-emitting component configured to emit light associated with the second wavelength, and a

third light-emitting component configured to emit light associated with a third wavelength, wherein the first light-emitting component, the second light-emitting component, and the third light-emitting component are physically separated from one another.

293. Yuen in view of Schröder teaches Claim 2 for the same reasons I discussed in Section VIII.D.2.a (Ground 4).

b. Claim 3: The wearable computing device of claim 1, wherein the one or more light-emitting components comprise a single light-emitting module configured to emit the light associated with the first wavelength, the second wavelength, and a third wavelength.

294. Yuen in view of Schröder teaches Claim 3 for the same reasons I discussed in Section VIII.D.2.b (Ground 4).

c. Claim 4: The wearable computing device of claim 1, wherein the one or more processors are further configured to: determine a first absorbance of the first wavelength, and a second absorbance associated with the second wavelength; and determine one or more characteristics of blood of the user based at least in part on the first absorbance and the second absorbance.

295. Yuen in view of Schröder teaches Claim 4 for the same reasons I discussed in Section VIII.D.2.c (Ground 4).

d. Claim 5: The wearable computing device of claim 4, wherein the one or more characteristics of the blood of the user comprise a blood alcohol level, a blood glucose level, a blood oxygenation level, or any combination thereof.

296. Yuen in view of Schröder teaches Claim 5 for the same reasons I discussed in Section VIII.D.2.d. (Ground 4).

e. Claim 6: The wearable computing device of claim 1, wherein the one or more processors are configured to: determine an ambient light level based at the one or more light-receiving components; and selectively adjust one or more operational parameters of the one or more light-emitting components based at least in part on the ambient light level, wherein processing the data is based at least in part on selectively adjusting the one or more operational parameters.

297. Yuen in view of Schröder teaches Claim 6 for the same reasons I discussed in Section VIII.D.2.e (Ground 4).

f. Claim 7: The wearable computing device of claim 6, wherein the one or more operational parameters comprise an intensity of the light emitted by the one or more light-emitting components.

298. Yuen in view of Schröder teaches Claim 7 for the same reasons I discussed in Section VIII.D.2.f (Ground 4).

g. Claim 8: The wearable computing device of claim 1, wherein the one or more processors are configured to: determine whether or not the user is wearing the wearable computing device based at least in part on the data acquired by the plurality of sensors; and selectively adjust one or more operational parameters of the plurality of sensors based at least in part on whether or not the user is wearing the wearable computing device.

299. Yuen in view of Schröder teaches Claim 8 for the same reasons I discussed in Section VIII.D.2.g (Ground 4).

h. Claim 9: The wearable computing device of claim 1, further comprising: a feedback component communicatively coupled with the one or more processors, wherein the feedback component is configured to provide feedback to the user based at least in part on the data acquired by the plurality of sensors.

Claim 10: The wearable computing device of claim 9, wherein the feedback comprises visual feedback, audible feedback, haptic feedback, or any combination thereof.

300. Yuen in view of Schröder teaches Claims 9 and 10 for the same reasons I discussed in Section VIII.D.2.h (Ground 4).

i. Claim 13: The wearable computing device of claim 1, further comprising: a power management module disposed within a cavity between the interior wall and the exterior wall, the power management module configured to wirelessly transfer energy from an external energy source to a battery of the wearable computing device through the interior wall, the exterior wall, or both.

301. Yuen in view of Schröder teaches Claim 13. Yuen teaches a cavity between the interior and exterior walls. Specifically, Yuen teaches that a cavity is formed on the inner (skin-facing) surface (red) of the biometric monitoring device, as shown in blue in Figures 4 and 7 (depicting a cross-sectional view of a PPG sensor). Ex-1006, Figs. 4, 7. As I discussed in Section V.B.2, by 2013 it was well understood that in order to house electronic components within wearable devices, there must be an internal space like a cavity between two housing portions. For

example, U.S. Patent No. 6,201,698 to Hunter teaches that "the side walls and the web together create a cavity [] to house the electronic circuit." Ex-1060, 2:56-57.

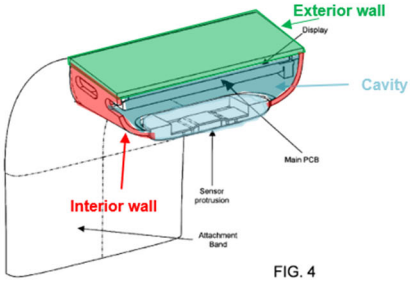


FIG. 4

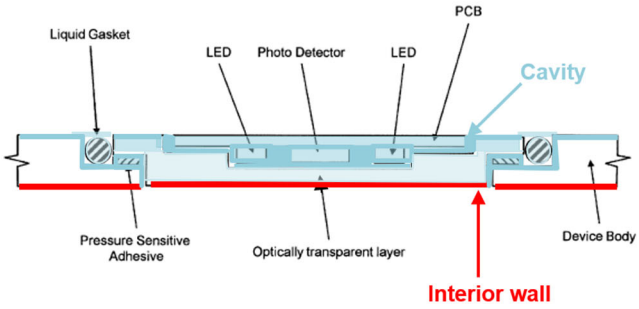


FIG. 7

302. Similarly, Schröder's finger ring consists of "two ring halves 16 and 18" with a recess so that "inlay 12 is inserted." Ex-1007, 12:7-9; *see also id.*, 8:56-57 (inlay 12 "arranged" in the interior). Like Yuen, Schröder's finger ring consist of an interior wall and an exterior wall as shown in Figure 4 and 8 below. Ex-1007, 12:7-8. A POSITA would have understood that Schröder's interior wall is the wall touching the finger of the user and the exterior wall is exposed to the environment.

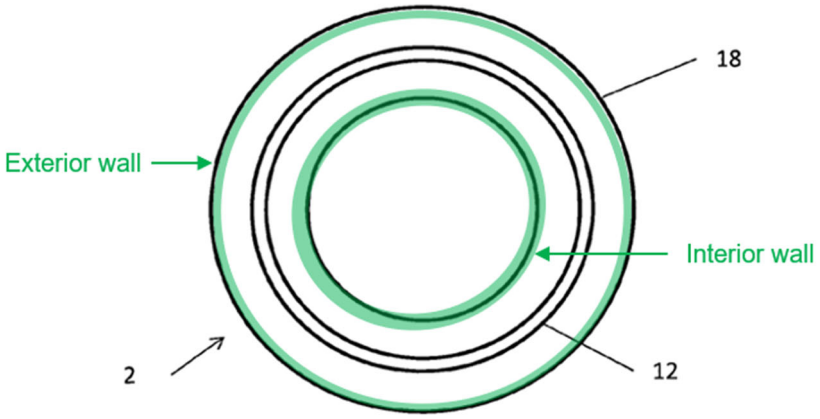


Fig. 4

Fig. 8

Ex-1007, Figs. 4 and 8.

303. Yuen-Schröder teaches a power management module disposed within a cavity between the interior and exterior walls. Schröder explains that inlay 12 can have a "chip module 10 with at least one antenna coil 8 with at least one further electronic device." Ex-1007, 12:61-65. Schröder also explains that an "energy storage device is connected to the chip module 10 in order to supply the chip module 10 with energy outside an electromagnetic field of a reader." *Id.*, 11:48-50. Schröder's "energy storage devices, e.g., an accumulator or a battery" is "charged by means of the reader's electromagnetic field." *Id.*, 11:46-55. Thus, A

POSITA would have understood that the battery being connected to chip module is arranged inside the finger ring's cavity to power the interior electrical components.

304. Yuen-Schröder's power management module wirelessly transfers energy from an external energy source to the finger ring's battery through a wall. Schröder's battery (energy storage device) is "connected directly to the antenna coil 8 via rectifier circuit" for charging. Ex-1007, 11:63-67. A POSITA would have understood that antenna coil 8 is the inductive charging component that is configured to wirelessly transfer energy form the "reader's magnetic field" to the battery. As I described in Section VIII.E.1, a POSITA would have been motivated to implement Schröder's wireless inductive charging to replace the wired connection charging in Yuen's device.

305. As I discussed in Section V.B.5, induction charging was widely used for charging batteries in wearable electronic devices. By 2013 wireless power transfer was used either for "real-time energy" or "to charge batteries" in biomedical devices. *See* Ex-1053, 1.

j. Claim 14: The wearable computing device of claim 13, wherein the power management module comprises an inductive charging component configured to transfer energy from the external energy source to the battery via an inductive charging process.

306. Yuen in view of Schröder teaches Claim 14. As I discussed in Section VIII.E.3.i (Claim 13) Schröder's is "connected directly to the antenna coil 8 via

rectifier circuit" and configured to wirelessly transfer energy from the "reader's magnetic field" to the battery. Ex-1007, 11:63-67. A POSITA would have understood that the charging process described in Schröder involves an inductive charging process.

307. As discussed in Section V.B.5, induction charging was widely used for charging batteries in wearable electronic devices.

k. Claim 15: The wearable computing device of claim 1, wherein the housing comprises: an internal housing component defining the interior wall; and an external housing component defining the exterior wall, the external housing component coupled to the internal housing component, wherein one of the internal housing component or the external housing component further defines a first side wall and a second side wall that extend between the internal housing component and the external housing component.

308. Yuen in view of Schröder teaches Claim 15. Yuen-Schröder's internal housing component defines the interior wall and is coupled to the external housing component which defines the exterior wall. Specifically, Schröder's finger- ring is defined by coupled external and internal housing components. As discussed above in Section VIII.E.3.i (Claim 13), Schröder's finger ring has a cavity between the internal and external housing components which houses and thus surrounds Schröder's inlay 12.

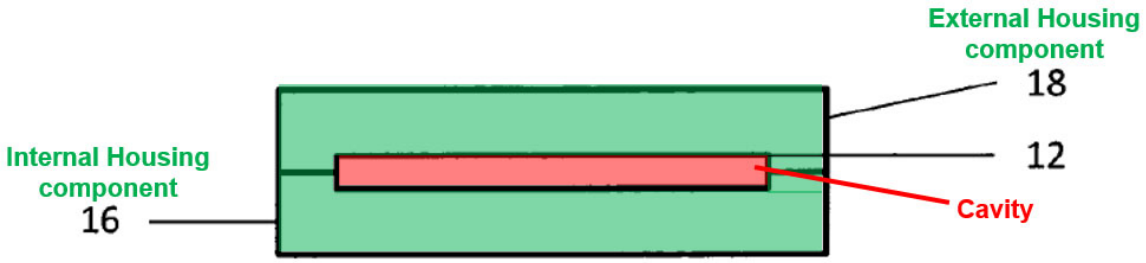


Fig. 7

Ex-1007, Fig. 7.

309. Also as previously discussed, Schröder's finger-ring consists of an internal housing component defining an interior wall and an external housing component defining an exterior wall. Ex-1007, 12:7-8.

310. Schröder's finger ring also includes internal and external housing components having a first and second side wall that extend between the internal and external housing components. Schröder states that ring halves 16 and 18 are manufactured by casting, milling, or embossing and are "interconnected by a suitable technology, e.g., by plugging, gluing, screwing, crimping, etc." Ex-1007, 12:10-22. Schröder provides various designs for the shape of the ring halves, such as a U-shape with inlay 12 being arranged between the components 16 and 18. *Id.*, 12:45-55. As shown in Figure 7 below, a POSITA would have understood that the U-shaped housing components are connected to each other and thus form "side walls" (red) that extend from external housing component 18 to internal housing component 16 and surround the cavity (occupied by inlay 12).

311. A POSITA would have understood that both housing components thus define a first side wall and a second side wall because both components are U-shaped. Similarly, in Figure 8, external housing portion 18 is a U-shape component that extends and connects to internal housing component 16. External housing portion 18 also defines the cavity by surrounding inlay 12 therefore having "side walls" (red) to form the connection. A POSITA would have understood that the external housing component defines the first and second side wall because it is U-shaped.

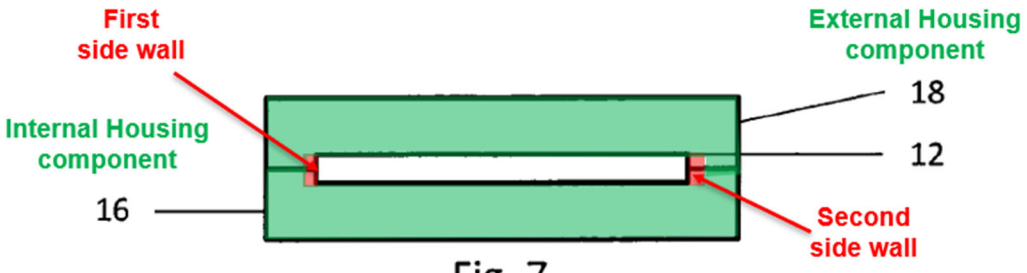


Fig. 7

Fig. 8

Ex-1007, Figs. 7, 8.

312. As I discussed in Section V.B.1 and V.B.2, wearable devices having an interior and exterior component was well-known. As I discussed in Section V.B.1 and V.B.2, wearable devices having an interior and exterior component was

well-known. For example, U.S. Patent No. 6,699,199 to Asada teaches that "one or more photo diodes 2 and one or more light-emitting diodes (LEDs) 4 are imbedded in a ring 10." Ex-1034, 2:59-61 (Asada '199). Moreover, U.S. Patent No. 6,745,061 to Hicks teaches that "[i]ncluded within the assembly 350 are upper and lower flexible members 304 and 300, respectively," which are "thermally bound to one another sandwiching a leadframe 308 between their inside surfaces." Ex-1025, 6:48-54. "This leadframe 308 contains active components (i.e., LEDs and a photodetector) for use in oximetry measurements." *Id*., 6:48-54 (Hicks).

l. Claim 16: The wearable computing device of claim 15, wherein the first side wall, the second side wall, or both, are substantially perpendicular to the interior wall, the exterior wall, or both.

313. Yuen in view of Schröder teaches Claim 16. Yuen-Schröder's first and second side walls are substantially perpendicular to the interior and exterior walls. As stated above for Claim 15, the side walls are the parts of the U-shaped components that extend from external housing component 18 to internal housing component 16 and surround the cavity to connect the housing components. As shown in Figure 8, a POSITA would have understood that Schröder's first and second side walls (red) are substantially perpendicular to the interior and exterior walls (green) because they are portions of the U-shaped components that extend to connect the housing components.

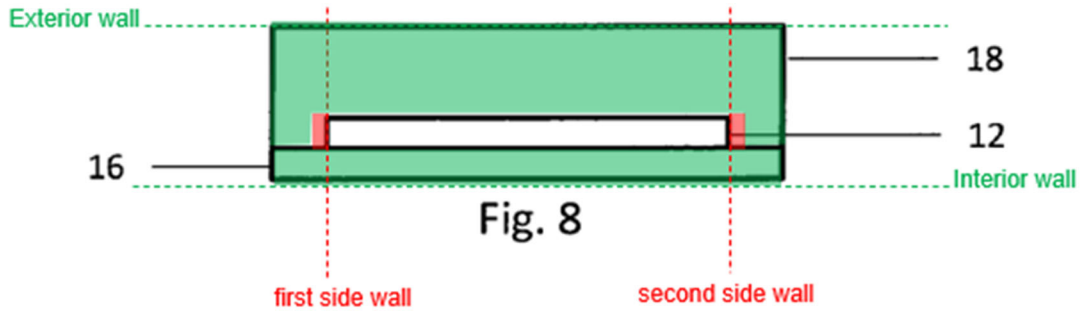


Fig. 8

314. Ex-1007, Fig. 8. A POSITA would have been motivated to implement side walls that are substantially perpendicular to the interior and exterior wall to improve the structure of the cavity and extend the longevity of the components.

F. Ground 6: Claims 11-12 Are Obvious Over Yuen (Ex-1006) in view of Niwa (Ex-1005)

1. A POSITA would have been motivated to combine the teachings of Yuen and Niwa, and would have had a reasonable expectation of doing so

315. A POSITA would have been motivated to combine the teachings of Yuen and Niwa ("Yuen-Niwa") and would have had a reasonable expectation of success in doing so because each relates to the same well-known technologies. Both are directed to wearable biometric sensing devices having similar structural components including, for example, a housing that includes light emitting sources and a light receiving portion disposed within the walls of the device. *See, e.g.*, Ex-1005 ¶191, ¶209; Ex-1006, 14:33-37, 6:24-31.

316. Yuen's biometric monitoring device can be worn on an appendage of

the user's body, for example, on the user's "arm, wrist, leg and/or ankle." Ex-1006, 2:7-17, 12:50-52. Yuen also teaches that the device can be "worn in any number of ways including, but not limited to" a chest band, necklace, patch, bra, earring, glasses, or "toe band." *Id*., 24:35-40. Niwa discloses that its wearable computing device has a finger ring construction "worn on the third joint of the finger." Ex-1005 ¶191.

317. A POSITA would have been motivated to combine the functionality of Yuen's biometric monitoring device with Niwa's finger ring construction because a POSITA would have found it beneficial to implement Yuen's device in a more compact form that is not intrusive or obtrusive and is easier for the user to remember to wear. Yuen teaches that the device housing should enable the device to be worn by the user without "measurably or appreciably impact[ing] the user's activity." Ex-1006, 23:63-67. Moreover, an exemplary structure that Yuen teaches for its device is a "toe band," which a POSITA would have understood is structurally equivalent and/or identical to a "finger ring." Niwa teaches that a finger ring is desirable because the finger ring construction allows the plethysmogram to be measured to fit the third joint of the finger. Ex-1005 ¶191. Thus, design incentives and market forces would have motivated a POSITA to apply the teachings of Niwa to Yuen.

318. Niwa also teaches various constructions of the plethysmogram sensor.

For example Niwa's plethysmogram sensor can include several light sensor modules with the light emitting portion and light receiving portion at different locations. Ex-1005 ¶164. Similarly, Yuen teaches that "the biometric monitoring device may consist of a plurality of photodetectors and photoemitters distributed along the surface of the device" such that the photodetectors and photoemitters touch the user's skin. Ex-1006, 19:3-7. A POSITA would have understood that having a wearable biometric sensing device that includes multiple light emitters and light receivers is beneficial to provide accurate and real-time information to the user about the user's health. Having multiple light emitters and light receivers also allows for redundancy, avoids the risk of an emitter or receiver being blocked by a skin occlusion, allows for better visualization of vascular tissue (because visualization is enabled at multiple locations), enhances signal-to-noise ratio, and helps to offset noise due to ambient environment light.

319. Thus, a POSITA would have understood that these references disclose interrelated teachings based on routine technologies that would have been amenable to various well-understood and predictable combinations to provide more features and enhance user interest.

2. Dependent Claims 11-12

a. Claim 11: The wearable computing device of claim 1, wherein the wearable computing device comprises a finger-worn wearable ring device, wherein the one or

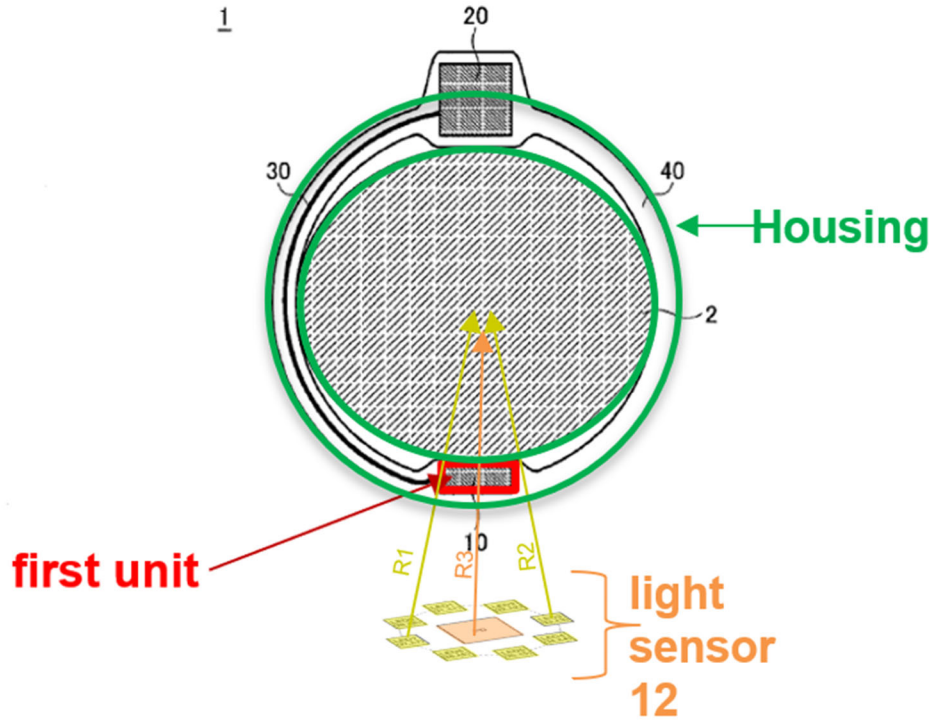
more light-emitting components comprise a first light-emitting component positioned within the housing of the finger-worn wearable ring device at a first radial position, and a second light-emitting component positioned within the housing of the finger-worn wearable ring device at a second radial position different from the first radial position.

320. Yuen-Niwa teaches Claim 11. As I discussed in Section VIII.F.1, Yuen's biometric monitoring device is a ring. A POSITA would have been motivated to implement Yuen's monitoring device as a finger ring, because it is an obvious design choice, as taught by Niwa. Niwa discloses that its wearable computing device has a finger ring construction that is "worn on the third joint of the finger." Ex-1005 ¶191. A POSITA would have been motivated to combine the teachings of Yuen and Niwa and would have had a reasonable expectation of success in doing so for the same reasons discussed in VIII.F.1.

321. Yuen-Niwa's finger ring device comprises a first light-emitting component positioned within the finger ring's housing at a first radial position and a second light-emitting component positioned at a second radial position. As I discussed in Section VIII.D.2.i (Claim 11, Ground 4), a POSITA would have understood Yuen's light sources are positioned a first and second radial position.

322. Niwa explains its plethysmogram sensor can have multiple light emitting and light receiving portions arranged in the finger ring's housing. As I discussed in Section VIII.A.2.e (Claim 11, Ground 1), Niwa's light sensor 12 (the

claimed light emitting component) has various light emitting components at different radial positions because Niwa describes Figure 3 as the "Layout of the Light Emitting Portion and the Light Receiving Portion" of the first unit's light sensor 12. Ex-1005 ¶119; *see also id*., ¶¶50, 200, Figs. 3, 27. When Figure 3 is in light sensor 12 (as exemplified below in modified Figure 22′), Niwa's LED7 (yellow) is positioned at a first radial position (R1) and LED3 (yellow) is positioned at a second radial position (R2) within the housing of the sensor (green). As explained above, LED7 and LED 3 are positioned at different radial positions because the LEDs are located at different circumferential positions along the curve of the ring, (i.e., the claimed "radial position"), just like in the '179 Patent. Ex-1001, Figs. 3B, 3C. A POSITA would have further understood that the LEDs would be at different radial positions because separation between the LEDs is important to enhance the quality of the plethysmogram signal and for redundancy within the device.



323. A POSITA would have been motivated to modify Yuen's biometric monitoring device to include Niwa's light sensors with LEDs at different radial positions to provide more accurate and real-time information to the user about the user's health. A POSITA would have understood that having an LED that emits infrared light positioned at a different radial position than an LED that emits visible light is important to capture different segments of tissues or for redundancy. Having multiple light emitting sources and light receiving portions also helps to enable an offset of noise caused by ambient light and sunlight. As described in Section VIII.F.1, a POSITA would have been motivated to implement Niwa's light sensor with its different radial positions into Yuen's device with a reasonable

expectation of success. A POSITA would have also understood that having the LEDs in a central circumference and away from the edges of the device, prevents light leakage from visible LEDs and interference from ambient light. *Id*.

b. Claim 12: The wearable computing device of claim 11, wherein at least one light-receiving component is positioned within the housing at a third radial position that is between the first radial position and the second radial position.

324. Yuen-Niwa teaches Claim 12. Yuen-Niwa teaches a light-receiving component positioned within the housing at a third radial position between the first and second radial positions. As discussed in Section VIII.D.2.j (Claim 12, Ground 4), a POSITA would have understood Yuen's photodetector is positioned within the housing at a third radial position that is between the first and second radial positions. *Id*. Niwa similarly has a photodetector positioned within the finger ring's housing at a third radial position that is between the first and second radial positions. Niwa discloses "multiple light emitting portions provided at different places [and] at least a single light receiving portion to detect each intensity of lights emitted from each of the multiple light emitting portions." Ex-1005 ¶32; *see also id*. ¶¶43, 117, Fig. 1. As shown above in modified Figure 22′, Niwa's light receiving portion PD (orange) is positioned at a third radial position (R3) that is between the first radial position (R1) of LED7 (yellow) and second radial position (R2) of LED3 (yellow) within the housing of the sensor (green).

325. A POSITA would have been motivated to modify Yuen's biometric monitoring device to include Niwa's light sensors with a light receiving portion at third radial position to provide more accurate and real-time information to the user about the user's health. Further, a POSITA would been motivated to have a photodetector positioned at a third radial position in Yuen, as taught in Niwa in order to receive the light emitted by the multiple LEDs for redundancy and to offset noise caused by ambient light or sunlight. A POSITA would have been motivated to combine the teachings of Yuen and Niwa and would have had a reasonable expectation of success in doing so for the same reasons discussed in VIII.E.1.

IX. CONCLUSION

326. For the reasons set forth above, I believe that Claims 1-16 of the '179 Patent is unpatentable in view of the prior art.

327. In signing this declaration, I recognize that it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

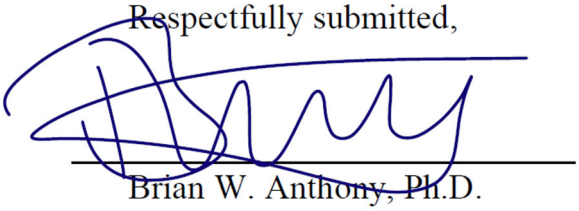
328. I reserve the right to supplement my opinions in the future to respond

to any arguments that the Patent Owner raises and to take into account new information as it becomes available to me.

329. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Dated: May 31, 2024

Respectfully submitted,



Brian W. Anthony, Ph.D.