

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

OURA HEALTH OY,
Patent Owner.

Case No. IPR2024-00929
U.S. Patent No. 10,893,833

**DECLARATION OF BRIAN W. ANTHONY
IN SUPPORT OF PETITION FOR INTER PARTES REVIEW
OF U.S. PATENT NO. 10,893,833**

TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
A. Qualifications	1
B. Materials Considered.....	6
II. LEGAL STANDARDS	10
A. Anticipation	11
B. Obviousness.....	12
C. Level of Ordinary Skill in the Art	15
D. Claim Construction	16
III. SUMMARY OF GROUNDS	17
IV. THE '833 PATENT.....	18
A. Overview of the '833 Patent.....	18
B. Prosecution History of the '833 Patent	21
V. TECHNOLOGY BACKGROUND.....	21
A. Wearable Electronic Devices Were Known.....	21
1. Photoplethysmography (PPG) sensors were well known.....	26
2. Beer's Law	28
3. Optical properties of human tissue	30
4. Pulse oximetry and oxygen saturation (SpO2)	31
5. Transmission of light as compared to the reflection of light	32
6. Multiple LEDs have been commonly used for biometric monitoring.....	34
7. Separation distance between LEDs and the photodiode is a design consideration for the quality of the acquired data	35
B. Wearable Electronic Device Arrangements.....	36
1. Wearable devices having inner and outer surfaces were known.....	36
2. Various ways to assemble electronic parts within	

TABLE OF CONTENTS
(continued)

	Page
structural cavities were known.....	37
3. Attaching electronics to a surface within an electronic device was known	46
4. Flexible PCBs and rigid-flex PCBs were known	49
5. Wireless inductive charging was known	51
C. Wearable Electronic Device Materials.....	53
1. Machinability of metallic materials was known.....	53
2. Using a moldable filler material to cover electronics was known.....	54
3. Windows and transparent materials were commonly used for emission and detection	64
a. Windows for optical transmission, such as light emission and detection.....	64
b. Windows for RF transmission and detection	75
D. Adjustment of Operational Parameters Was Known	78
VI. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS	81
A. Yuen (U.S. Patent No. 8,954,135) (Ex-1006).....	81
B. Schröder (U.S. Patent No. 10,303,867) (Ex-1007)	82
VII. CLAIM CONSTRUCTION	84
VIII. DETAILED EXPLANATION OF THE UNPATENTABILITY GROUNDS	85
A. Ground 1: Claims 1-11 are obvious over Yuen.	85
1. Independent Claim 1	85
a. Element 1[pre]: A wearable electronic device comprising:	85
b. Element 1[a]: a body part made of a non-ceramic material, ...	86
c. Element 1[b]: having an inner surface and an outer surface,.....	88

TABLE OF CONTENTS

(continued)

	Page
d. Element 1[c]: wherein at least one cavity is formed on the inner surface of the body part, ...	91
e. Element 1[d]: the at least one cavity extending from the inner surface of the body part towards the outer surface of the body part and having a depth arranged within the inner surface of the body part, ...	95
f. Element 1[e]: an electronic part arranged in said at least one cavity, ...	100
g. Element 1[f]: which electronic part has a thickness that is less than the depth of the at least one cavity, and.....	107
h. Element 1[g]: a coating made of a moldable filler material on the inner surface of the body part, covering the electronic part and the at least one cavity.....	109
2. Dependent Claims 2-11.....	118
a. Claim 2: The wearable electronic device according to claim 1, wherein the non-ceramic material is a titanium material.	118
b. Claim 3: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable material.....	119
c. Claim 4: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable titanium material.	121
d. Claim 5: The wearable device according to claim 1 wherein the non-ceramic material is a machinable metallic material comprising one or more of titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys.	122

TABLE OF CONTENTS
(continued)

	Page
e. Claim 6: The wearable electronic device according to claim 1, wherein the electronic part is attached to the [at least one] cavity [at] a bottom of the [at least one] cavity.	124
f. Claim 7: The wearable electronic device according to claim 6, comprising one or more of a sticker, a tape or glue that attaches the electronic part to the at least one cavity at a bottom of the at least one cavity.....	131
g. Claim 8: The wearable electronic device according to claim 1, wherein the moldable filler material is selected from a group consisting of at least epoxy material, Polyethylene, Polyurethane, low temperature moldable material, Loctite M-31CL, alpha-epoxy, 1,2-epoxy, EpoxAcast® 650, Bisphenol S epoxy resin, Novolac epoxy resin, Aliphatic epoxy resin and Glycidylamine epoxy resin.....	133
h. Claim 9: The wearable electronic device according to claim 1, wherein the electronic part comprises one or more of a battery, an infrared transmitter, a microcontroller, a radio frequency transceiver, a temperature sensor and an infrared receiver.....	138
i. Claim 10: The wearable electronic device according to claim 9, wherein the moldable filler material comprises an ink and is configured to cover at least an area other than the infrared transmitter and the infrared receiver within the at least one cavity.	142
j. Claim 11: The wearable electronic device according to claim 1, wherein the moldable filler material comprises an ink that increases a value of transmitted infrared light intensity divided by transmitted visible light intensity.	146

TABLE OF CONTENTS
(continued)

	Page
B. Ground 2: Claim 12 is obvious over Yuen in view of Schröder.....	150
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.....	150
2. Dependent Claim 12: The wearable electronic device according to claim 1, wherein the body part comprises a ring configured to be worn on a finger.	160
C. Ground 3: Claims 1-5, 7-9, and 12 are obvious over Schröder.	167
1. Independent Claim 1	167
a. Element 1[pre]: A wearable electronic device comprising:	167
b. Element 1[a]: a body part made of a non-ceramic material, ...	168
c. Element 1[b]: having an inner surface and an outer surface, ...	171
d. Element 1[c]: wherein at least one cavity is formed on the inner surface of the body part, ...	174
e. Element 1[d]: the at least one cavity extending from the inner surface of the body part towards the outer surface of the body part and having a depth arranged within the inner surface of the body part, ...	180
f. Element 1[e]: an electronic part arranged in said at least one cavity, ...	186
g. Element 1[f]: which electronic part has a thickness that is less than the depth of the at least one cavity, and.....	192
h. Element 1[g]: a coating made of a moldable filler material on the inner surface of the body part, covering the electronic part and the at least one cavity.....	194
2. Dependent Claims 2-5, 7-9, and 12	202

TABLE OF CONTENTS
(continued)

	Page
a. Claim 2: The wearable electronic device according to claim 1, wherein the non-ceramic material is a titanium material.....	202
b. Claim 3: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable material.....	203
c. Claim 4: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable titanium material.	204
d. Claim 5: The wearable device according to claim 1 wherein the non-ceramic material is a machinable metallic material comprising one or more of titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys.	206
e. Claim 8: The wearable electronic device according to claim 1, wherein the moldable filler material is selected from a group consisting of at least epoxy material, Polyethylene, Polyurethane, low temperature moldable material, Loctite M-31CL, alpha-epoxy, 1,2-epoxy, EpoxAcast® 650, Bisphenol S epoxy resin, Novolac epoxy resin, Aliphatic epoxy resin and Glycidylamine epoxy resin.....	207
f. Claim 9: The wearable electronic device according to claim 1, wherein the electronic part comprises one or more of a battery, an infrared transmitter, a microcontroller, a radio frequency transceiver, a temperature sensor and an infrared receiver.....	211
g. Claim 12: The wearable electronic device according to claim 1, wherein the body part comprises a ring configured to be worn on a finger....	215
D. Ground 4: Claims 6-7 and 10-11 are obvious over Schröder in view of Yuen.	220

TABLE OF CONTENTS
(continued)

	Page
1. A POSITA would have been motivated to combine Schröder's teachings with Yuen's teachings and would have had a reasonable expectation of success.	220
2. Dependent Claims 6-7 and 10-11	232
a. Claim 6: The wearable electronic device according to claim 1, wherein the electronic part is attached to the [at least one] cavity [at] a bottom of the [at least one] cavity.	232
b. Claim 7: The wearable electronic device according to claim 6, comprising one or more of a sticker, a tape or glue that attaches the electronic part to the at least one cavity at a bottom of the at least one cavity.....	240
c. Claim 10: The wearable electronic device according to claim 9, wherein the moldable filler material comprises an ink and is configured to cover at least an area other than the infrared transmitter and the infrared receiver within the at least one cavity.	241
d. Claim 11: The wearable electronic device according to claim 1, wherein the moldable filler material comprises an ink that increases a value of transmitted infrared light intensity divided by transmitted visible light intensity.	246
IX. CONCLUSION.....	250

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 an inter partes review (“IPR”) proceeding of U.S. Patent No. 10,893,833 (“the ’833 Patent”) (Ex 1001), currently assigned to Oura Health Oy (“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 ’833 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 August 14, 2015. Based on the prior art discussed in this declaration, it is my opinion that Claims 1-12 of the ’833 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 ’833 Patent’s earliest possible priority date—addressed the same system issues as those described and claimed in the ’833 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 '833 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 '833 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 '833 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 '833 Patent. I teach or have taught courses in Manufacturing Engineering, Smart Manufacturing, Industrial Internet of Things all pertinent subject

matter to the '833 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 '833 Patent. We develop polymer based devices and sensors to 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 '833 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-

U.S. Patent No. 10,893,833
Declaration of Brian W. Anthony
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. 10,893,833 (“the ’833 Patent)
Ex-1004	Prosecution History of U.S. Patent No. 10,893,833

Ex. No.	Description
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	U.S. Patent Publication No. 20140244009 to Mestas (“Mestas”)
Ex-1011	INTENTIONALLY LEFT BLANK
Ex-1012	INTENTIONALLY LEFT BLANK
Ex-1013	U.S. Patent Publication No. 20120218184 to Wissmar (“Wissmar”)
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	Claim Construction Order, <i>Oura Health Oy v. Circular SAS</i> , No. 22-cv-00478-ADA (W.D. Tex. Feb. 2, 2024)
Ex-1022	Parallel Citations (Schröder ’867 to Certified Translation of DE 102013012339.9)
Ex-1023	INTENTIONALLY LEFT BLANK
Ex-1024	U.S. Patent No. 4,830,014 to Goodman (“Goodman”)

Ex. No.	Description
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., <i>Reflectance Pulse Oximetry – Principles and Obstetric Application in the Zurich System</i> , 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., <i>Pulse Oximetry</i> , 70 Journal of American Society of Anesthesiologists, Inc. (Jan. 1989) (“Tremper”)
Ex-1030	Y. Mendelson et al., <i>A Wearable Reflectance Pulse Oximeter for Remote Physiological Monitoring</i> , Proceedings of 28 th IEEE EMBS Annual International Conference (Aug. 30-Sept. 3, 2006) (“Mendelson 2006”)
Ex-1031	Sokwoo Rhee et al., <i>Artifact-Resistant, Power-Efficient Design of Finger-Ring Plethysmographic Sensors Part I: Design and Analysis</i> , IEEE (2000) (“Rhee 2000 Part I”)
Ex-1032	Sokwoo Rhee et al., <i>Artifact-Resistant, Power-Efficient Design of Finger-Ring Plethysmographic Sensors Part II: Prototyping and Benchmarking</i> , IEEE Proceedings of 22 nd Annual EMBS Int’l Conference (July 23-28, 2000) (“Rhee 2000 Part II”)
Ex-1033	Sokwoo Rhee et al., <i>Artifact-Resistant Power-Efficient Design of Finger-Ring Plethysmographic Sensors</i> , 48 IEEE Transactions of Biomedical Engineering (July 2001) (“Rhee 2001”)
Ex-1034	U.S. Patent No. 6,699,199 to Asada (“Asada ’199”)
Ex-1035	Sokwoo Rhee, <i>Design and Analysis of Artifact-Resistive Finger Photoplethysmographic Sensors for Vital Sign Monitoring</i> , MIT (June 2000) (“Rhee Thesis 2000”)
Ex-1036	C.T. Olofson et al., <i>Machining of Titanium Alloys</i> (1965) (“Olofson”)

Ex. No.	Description
Ex-1037	H. Harry Asada et al., <i>Mobile Monitoring with Wearable Photoplethysmographic Biosensors</i> , IEEE Engineering in Medicine & Biology Magazine 28 (May-June 2003) (“Asada 2003”)
Ex-1038	Denisse Castaneda et al., <i>A review on wearable photoplethysmography sensors and their potential future applications in health care</i> , Int J Biosens Bioelectron (2018)
Ex-1039	U.S. Patent No. 7,468,036 to Rulkov et al. (“Rulkov”)
Ex-1040	U.S. Patent Publication No. 2006/0211924 to Dalke et al. (“Dalke”)
Ex-1041	<i>Guidelines To Enhancing The Heart-Rate Monitoring Performance Of Biosensing Wearables</i> (2014)
Ex-1042	U.S. Patent No. 4,880,304 to Jaeb et al. (“Jaeb”)
Ex-1043	Tom Lister et al., <i>Optical Properties of human skin</i> , Journal of Biomedical Optics (2012)
Ex-1044	John G. Webster, <i>Design of Pulse Oximeters</i> , 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-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., <i>Episodic Sampling: Towards Energy-Efficient Patient Monitoring with Wearable Sensors</i> , Annual International Conference of the IEEE Engineering in Medicine and Biology Society (2009)

Ex. No.	Description
Ex-1052	Anastasios Petropoulos et al., <i>Flexible PCB-MEMS flow sensor</i> , Procedia Engineering 47 236-239 (2012) (“Petropoulos”)
Ex-1053	Tianjia Sun et al., <i>Wireless Power Transfer for Medical Microsystems</i> , Springer (2013) (“Sun”)
Ex-1054	U.S. Patent Pub. No. 2014/0187160 to Prencipe (“Prencipe”)
Ex-1055	H. Ardebili and Michael G. Pecht, <i>Encapsulation Technologies for Electronic Applications</i> , William Andrew (2009) (“Ardebili”)
Ex-1056	Ciprian Ciofu et al., <i>Injection and Micro Injection of Polymeric Plastics Materials: A Review</i> , Int’l J. Modern Mfg. Techs. 49 (2013)
Ex-1057	Richard J. Ross, <i>LCP Injection Molded Packages—Keys to JEDEC I Performance</i> , IEEE, 2004 Electronic Components and Technology Conference 1807 (2004)
Ex-1058	Tadamoto Sakai, <i>Encapsulation Process for Electronic Devices Using Injection Molding Method</i> , 12 Advances in Polymer Technology 61 (1993)
Ex-1059	N.J. Teh et al., <i>Embedding of Electronics within Thermoplastic Polymers using Injection Moulding Technique</i> , IEEE, 2000 Int’l Electronics Manufacturing Technology Symposium 10 (2000)
Ex-1060	U.S. Patent No. 6,201,698 to Hunter (“Hunter”)
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 ’833 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. 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 have recognized 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 '833 Patent or any assignee of the '833 Patent that any secondary considerations tend to rebut the obviousness of the '833 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 August 14, 2015 (“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

34. I understand that Petitioner challenges the validity of Claims 1-12 of the '833 Patent. It is my opinion that the following grounds demonstrate that the claims of the '833 Patent are invalid.

Ground	Summary
1	Claims 1-11 are obvious over Yuen (Ex-1006).
2	Claim 12 is obvious over Yuen in view of Schröder (Ex-1007).

Ground	Summary
3	Claims 1-5, 8-9, and 12 are obvious over Schröder.
4	Claims 6-7 and 10-11 are obvious over Schröder in view of Yuen.

IV. THE '833 PATENT

A. Overview of the '833 Patent

35. The challenged claims of the '833 Patent are directed to a wearable electronic device having specific components including an inner surface, an outer surface, a cavity, an electronic part arranged in the cavity, and a moldable filler material that covers the electronic part and the cavity. Ex-1001, Cl. 1.

36. An example of the wearable electronic device is illustrated in Figures 3 and 7C, below, of the '833 Patent.¹ *Id.*, Fig. 3 (showing a cross-sectional view of the device 102), Fig. 7 (showing a cross-sectional view of the inner surface 110 of the device 102). As shown in these figures, a cavity (annotated in blue (302, 304)) is bounded by the inner surface (annotated in red (110)). The inner surface extends toward the outer surface (not labelled) of the device. *Id.*, 10:38-41. An electronic part (annotated in purple (310, 312, 314)), which may include, for example, a battery, microcontroller, an infrared (IR) transmitter, an IR receiver, a RF (radio frequency)

¹ Throughout, I have added emphasis and annotations unless otherwise specified.

transceiver, a temperature sensor, and/or flexible printed circuit board (“PCB”), is arranged in the cavity and “has a thickness that is less than the depth of the” cavity. *Id.*, 10:47-11:4 (“still an unfilled space remains” in the cavity after the electronic parts are arranged therein). A coating made of a moldable filler material 330 (annotated in yellow) is applied on the inner surface 110 to cover the electronic part and the cavity such that any unfilled space in the cavity is coated by the moldable filler material. *Id.*, 11:5-16.

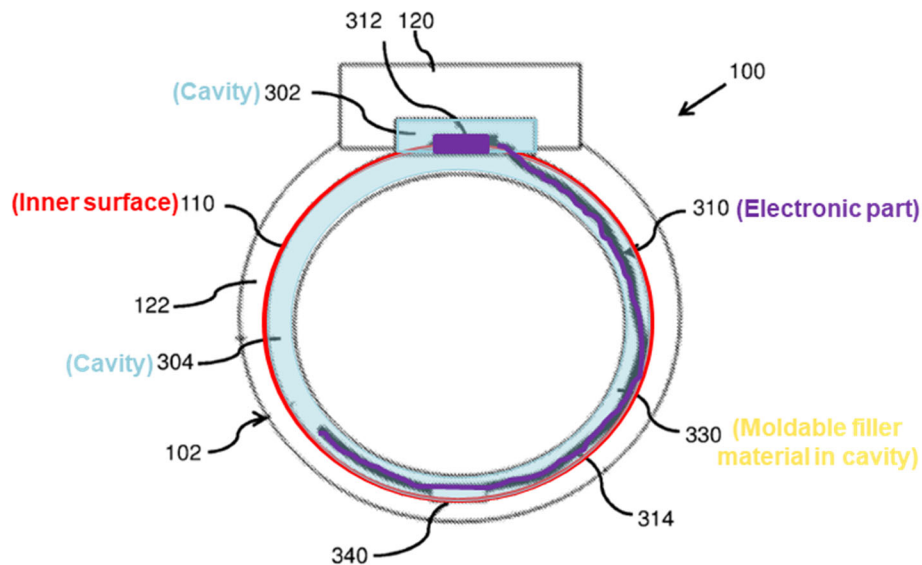


FIG. 3

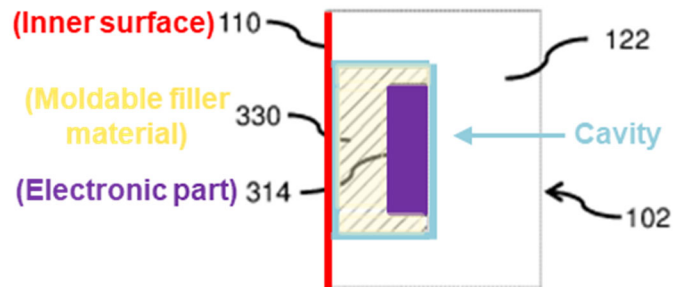


FIG. 7C

37. The '833 Patent recognizes that electronic devices that could be worn on the “finger, wrist or any other body part” to monitor physiological parameters of the user (such as heartbeat) and provide “a smooth skin contact to the wearer” were well-known, including the electronic elements included in such devices. *Id.*, 1:23-36 (“[W]earable electronic devices for monitoring personal health are well known in the art. The wearable electronic devices are measurement devices that can be worn on the finger, wrist, or any other body part. Generally, such devices include electronic elements such as flexible printed circuit board, processor, sensor, battery and the like, which enable measurement and/or analysis of different physiological parameters, such as heart beat, corresponding to a user.”). Yet the patent suggests that the claimed wearable electronic device is somehow inventive and patentable over the prior art because it has “a simple structure configuration and efficient waterproofing.” Ex-1001, 2:25-29 (“Embodiments of the present disclosure substantially eliminate or at least partially address the aforementioned problems in

the prior art, and provides a wearable electronic device having a simply structure configuration and efficient waterproofing.”). As explained in detail below, it is my opinion that the ’833 Patent claims are obvious in view of the prior art.

B. Prosecution History of the ’833 Patent

38. The ’833 Patent was filed December 8, 2017, as a continuation of U.S. Patent No. 9,861,315, filed August 14, 2015. Ex-1001. I apply the earliest alleged priority date of the ’833 Patent for my analysis herein, which I understand is August 14, 2015.

39. I understand that this Petition presents arguments not considered during prosecution. *See* Ex-1004. I also understand that the prior art in this Petition was not before the PTO during prosecution. *Id.*

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, lightweight, and unobtrusive wearable devices may facilitate remote noninvasive monitoring of vital signs[.]”).

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.

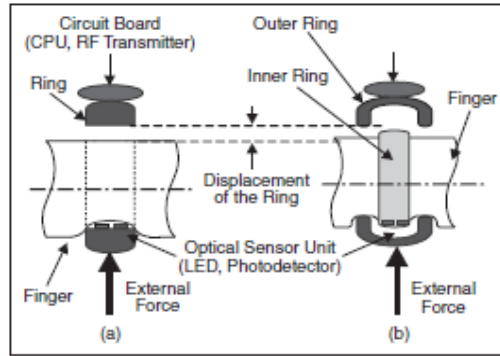


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force [31].

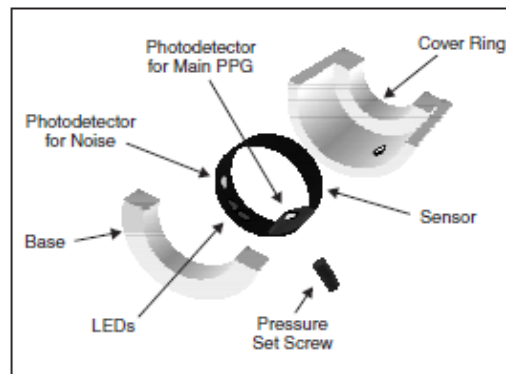


Fig. 15. The schematic of the Prototype C ring sensor.

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 PPG [photoplethysmograph] 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 shown in Figure 1. *Id.*, 0003, 0014.

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: $A = \epsilon \cdot b \cdot c$. 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.*

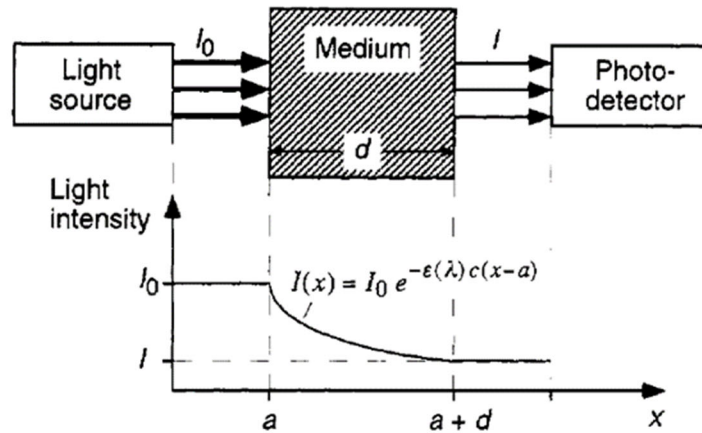


Figure 4.1 Beer's law: Incident light of intensity I_0 travels the distance a from a light source to the medium without being absorbed in the air. The light intensity decreases exponentially with distance in the absorbing medium. The intensity of the transmitted light I is determined by Beer's law. It 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.

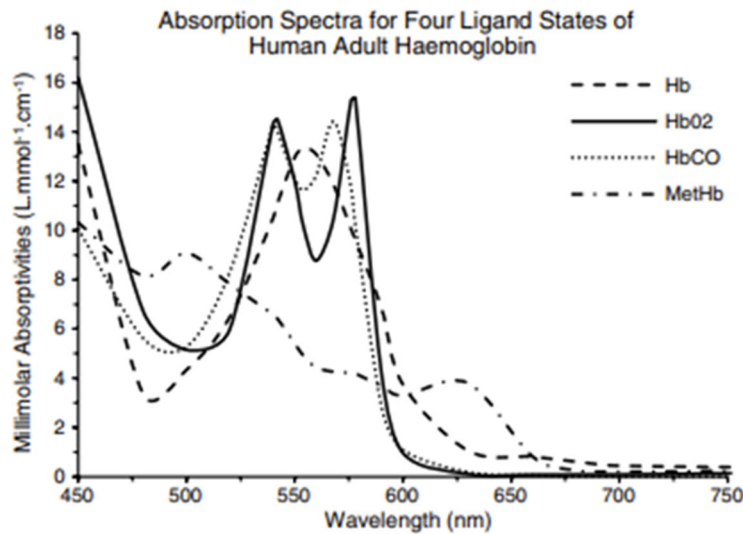


Fig. 1 Absorption spectra of deoxyhemoglobin (Hb), oxyhemoglobin (HbO₂), carboxyhemoglobin (HbCO), and methemoglobin (MetHb) in the visible region, from Ref. 27.

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 (SpO₂) 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 (SaO₂) to estimate peripheral SpO₂.

57. The calculation of arterial oxygen saturation (SpO₂) using a PPG involves analyzing the photoplethysmograph 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: $SpO_2 = (Oxy-Hb) / (Oxy-Hb + Deoxy-Hb) \times 100\%$.

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.

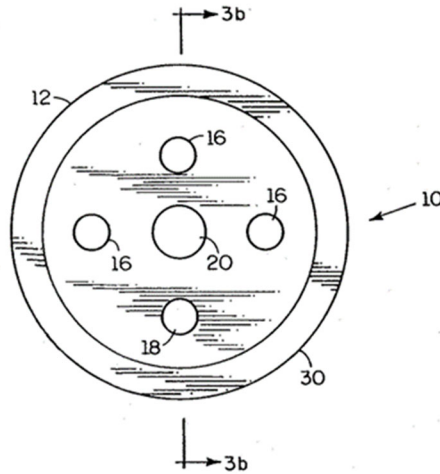


FIG. 3a

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).

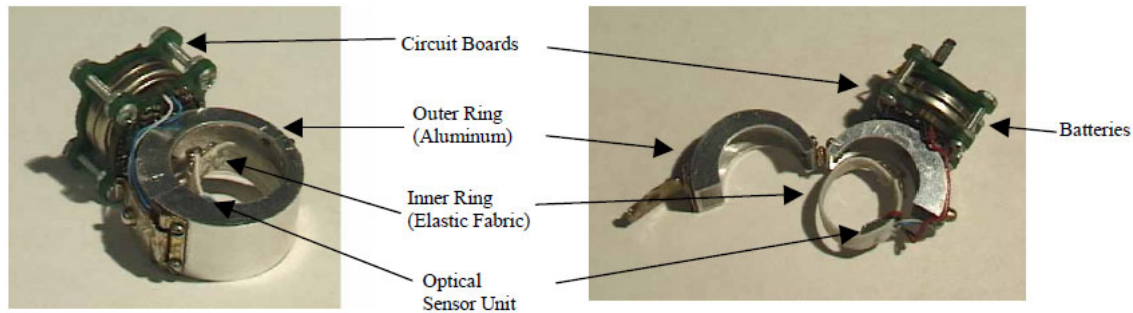


Figure 1 : Isolating ring sensor designed for motion artifact minimization

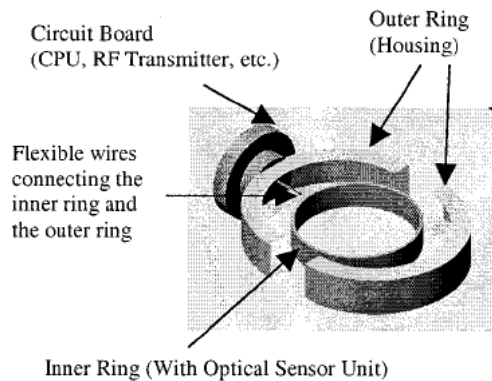


Fig. 3. Construction of isolating ring.

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, optical 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 and were widely known as of 2013. 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 and were known in 2013. 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 and were also known by 2013.

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 was common as of 2013.

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.

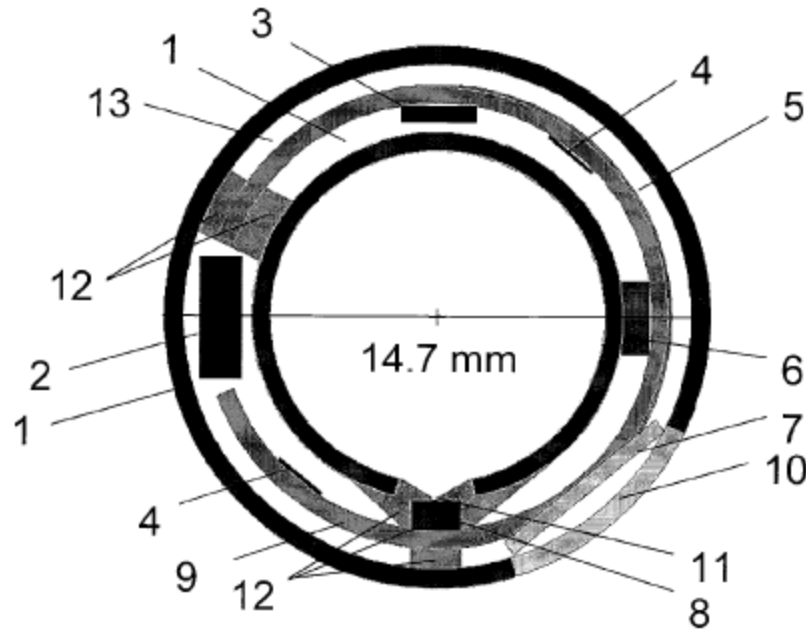


Fig. 1

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.

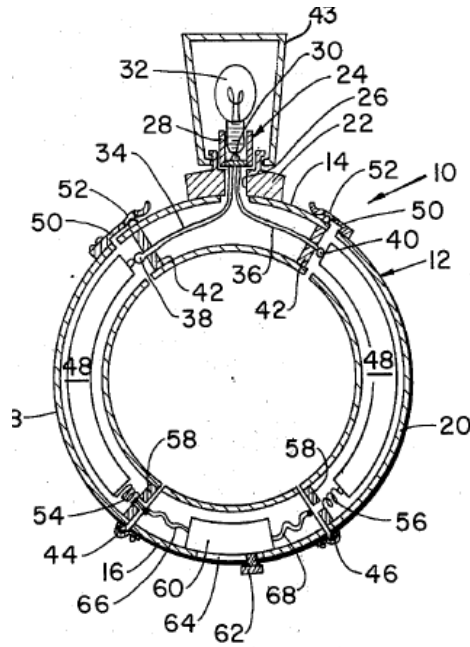


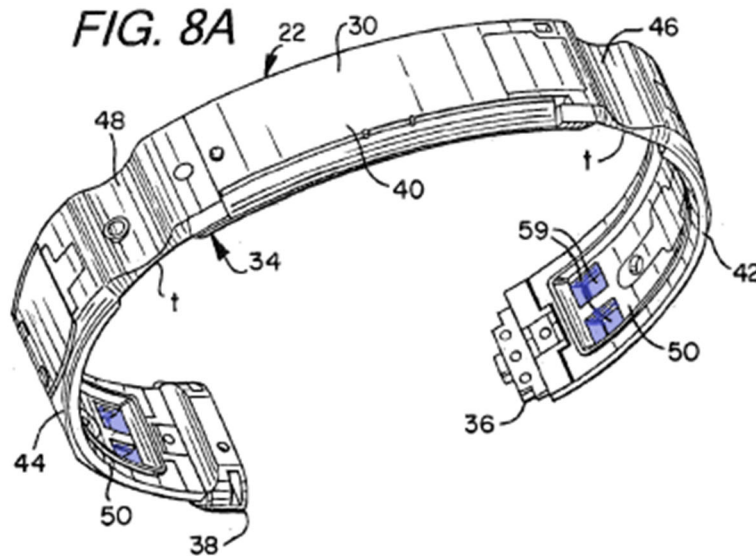
FIG. 2

79. Moreover, U.S. Patent Publication No. 20140244009 to Mestas teaches an electronic wearable device that has “compartments” for its electronic components. Mestas’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, for example, injection molding or potting, 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.2.

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).

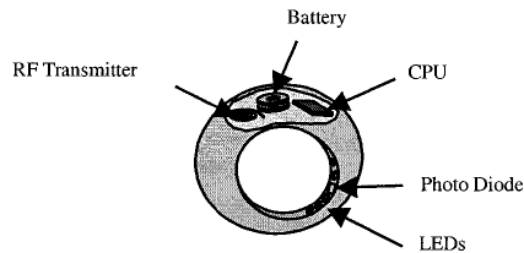


Fig. 1. Conceptual diagram of the ring sensor.

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 module 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).

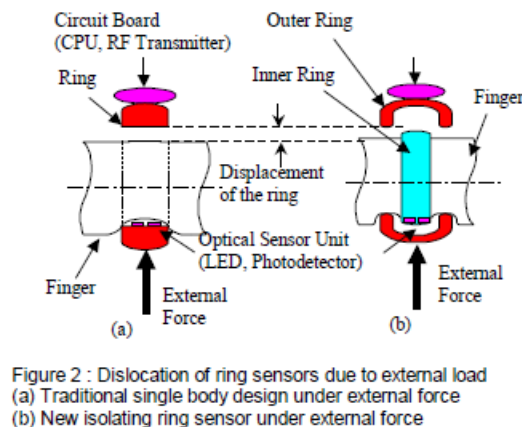
3. Attaching electronics to a surface within an electronic device was known

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).



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 PCBs and rigid-flex PCBs were 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.

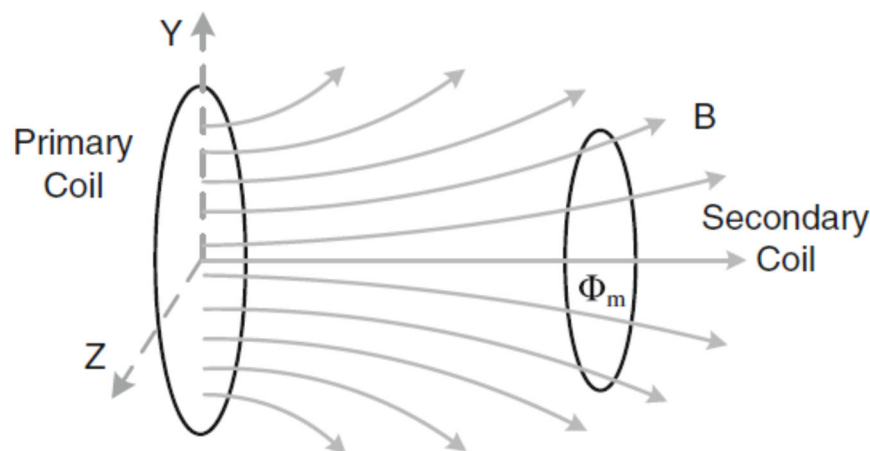
5. Wireless inductive charging was known

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 types 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 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.

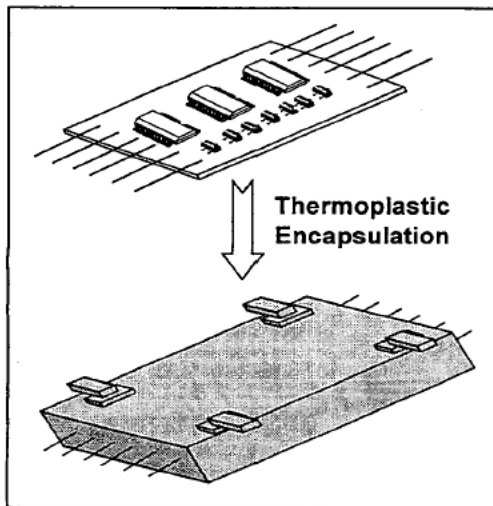


Figure 1. Illustration of the electronic overmoulding

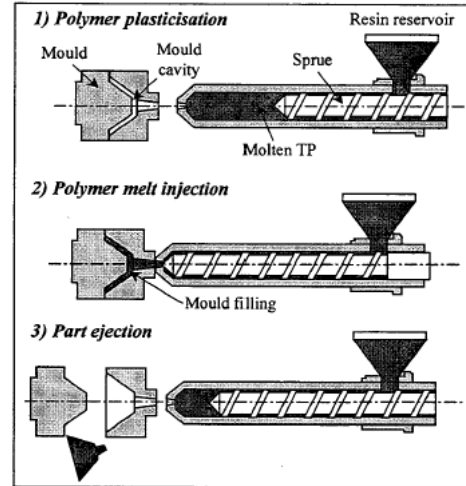


Figure 2. Schematic diagram of injection moulding

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). 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 [micro-electromechanical system] suspension sensor chip that includes a cavity constructed on the back surface. Figure 8.12(b) shows selective plastic encapsulation of a MEMS 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.”).

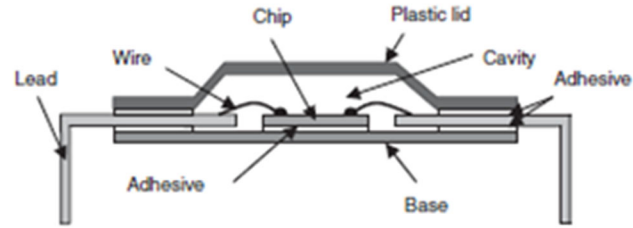


Figure 1.5 A pre-molded plastic package [9].

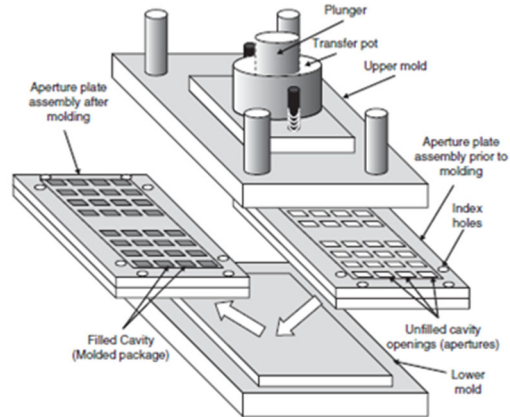


Figure 3.4 Aperture-plate (or cavity plate) molding setup [3].

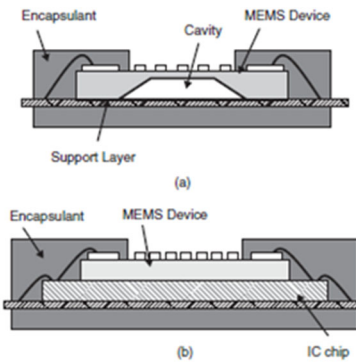


Figure 8.12 Plastic-encapsulated MEMS device package designs from Industrial Technology Research Institute: (a) MEMS device with a cavity; (b) 3D package with a MEMS device stacked on an IC chip [21].

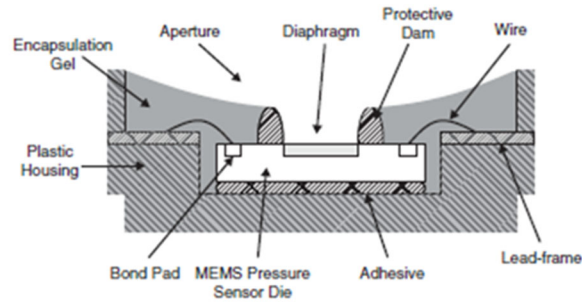


Figure 8.13 Plastic-encapsulated MEMS pressure sensor device from Motorola [22].

99. 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.”).

100. 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”).

101. U.S. Patent No. 6,745,061 to Hicks 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.”).

102. 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.

103. Yuen further emphasizes the importance of having a watertight seal of the device. *See, e.g., id.*, 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.

104. 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 is toleranced 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 carried 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

105. 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.

106. 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.

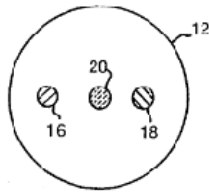


FIG. 2a

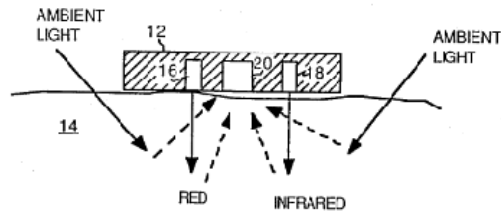


FIG. 2b

107. 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.

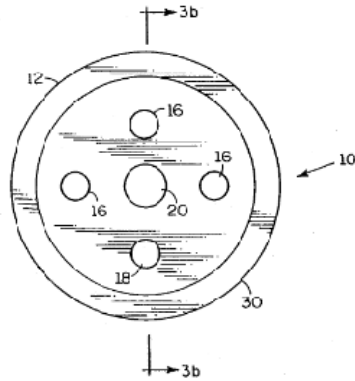


FIG. 3a

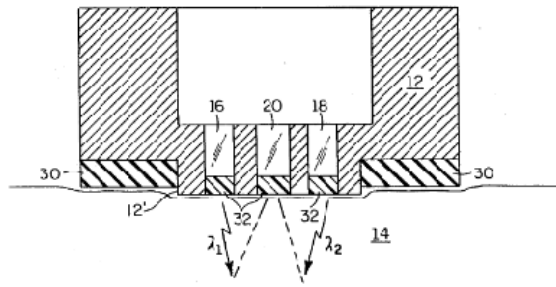


FIG. 3b

108. 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.").

109. 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.

110. 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.

111. Yuen explains that the windows can also be used on the exterior of the hosing. 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.

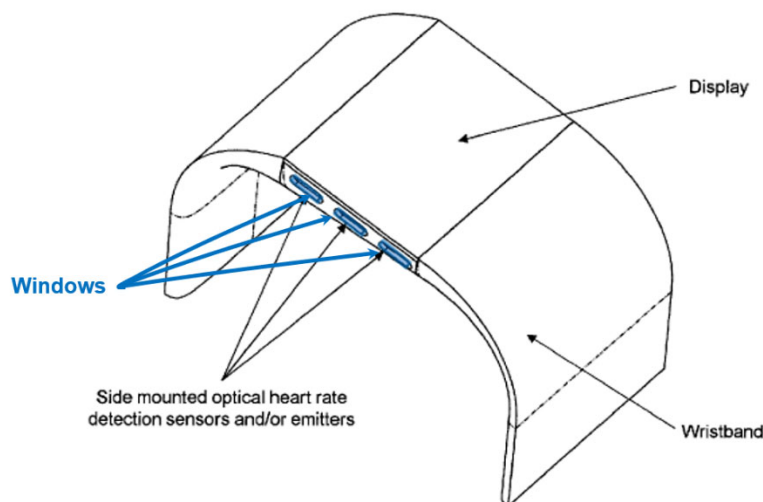


FIG. 12

112. 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).

113. 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

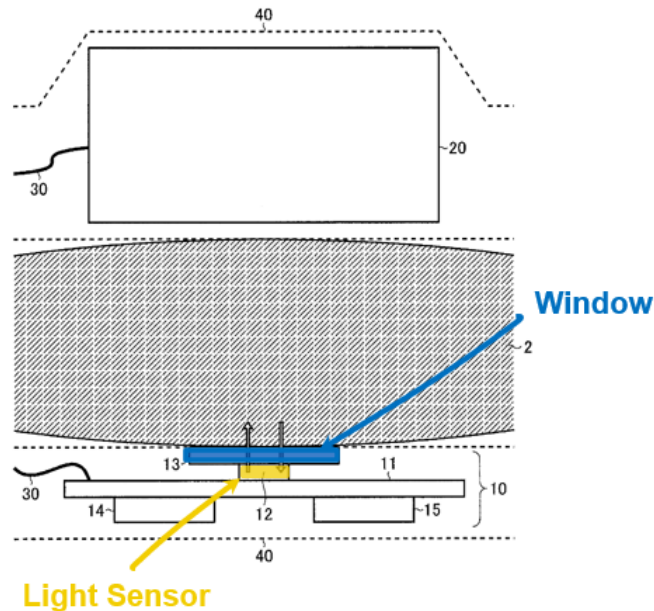
receives reflected light in a second window. When the heart beats, blood flow increases temporarily and more red blood cells flow through the windows, which increases the light reflected back to the detector. The light can be reflected, refracted, scattered, and absorbed by one or more detectors. Suitable noise reduction is done, and the resulting optical waveform is captured by the CPU.” Ex-1045 ¶295.

114. 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.

115. 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 a 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



116. 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 SpO₂ by:

- a) directing light beams against the mixture;
- b) determining at least one blood characteristic other than SpO₂ 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, SpO₂, of the mixture by analyzing the intensity of the light transmitted through the mixture.

Ex-1046, 0005 (page numbered 4).

117. 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.

118. WO 2011/132009 to Nyiradi (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).

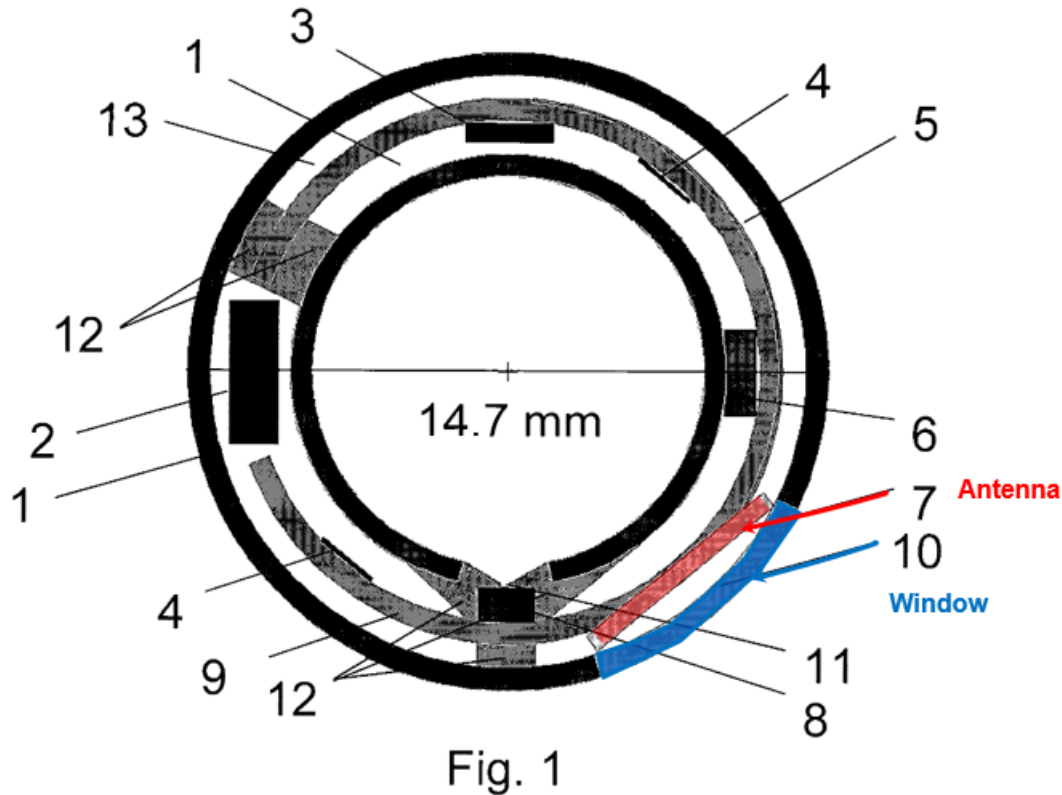
119. Therefore, windows and transparent materials for optical transmission were well-known in order to focus the light from a light-emitting component, such as a light emitting diode, to be emitted through and reflected back to the light receiving component, such as a photodetector.

b. Windows for RF transmission and detection

120. 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.

121. 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.



122. 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.

123. 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.

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

D. Adjustment of Operational Parameters Was Known

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

126. 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.

127. 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.

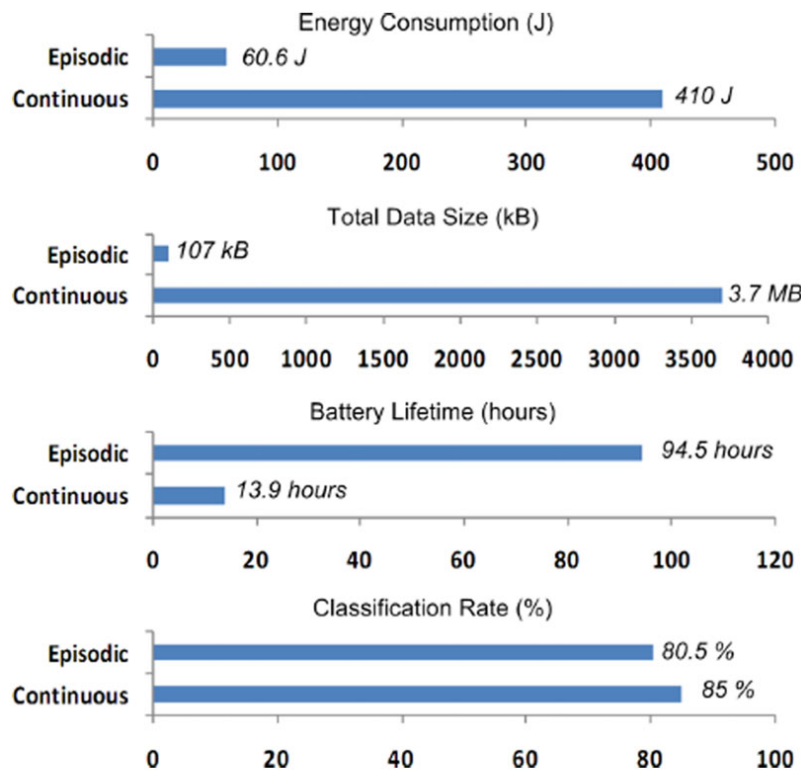


Fig. 5.
Experimental Results - Continuous vs. Episodic Sampling

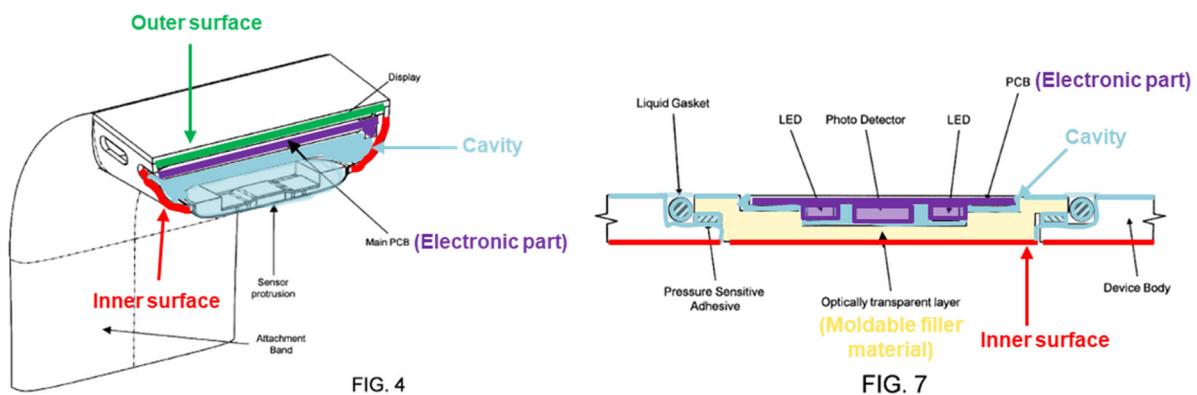
128. Thus, adjusting measurement periodicity was known in wireless healthcare applications. Therefore, it was well-known that adjusting a sensor’s operational parameters or measurement periodicity based on a user’s activity or sensor information could reduce power consumption of a device.

VI. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. Yuen (U.S. Patent No. 8,954,135) (Ex-1006)

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

130. Yuen teaches a portable biometric monitoring device, depicted in Figures 4 and 7 below, which 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." Ex-1006, 12:50-52, Fig. 4 (depicting a cross-sectional view of the device), Fig. 7 (depicting a cross-sectional view of the device's photoplethysmography ("PPG") sensor).



131. As depicted in the figures above, Yuen teaches that a cavity (annotated in blue) is formed on the inner surface (annotated in red (110)), which extends to the outer surface (Fig. 4 (annotated in green), Fig. 7 (not shown)) of the device. *Id.* The cavity houses Yuen's electronic part (annotated in purple) including, for example, "an optical sensor having one or more light sources" (such as LEDs) that emit "light

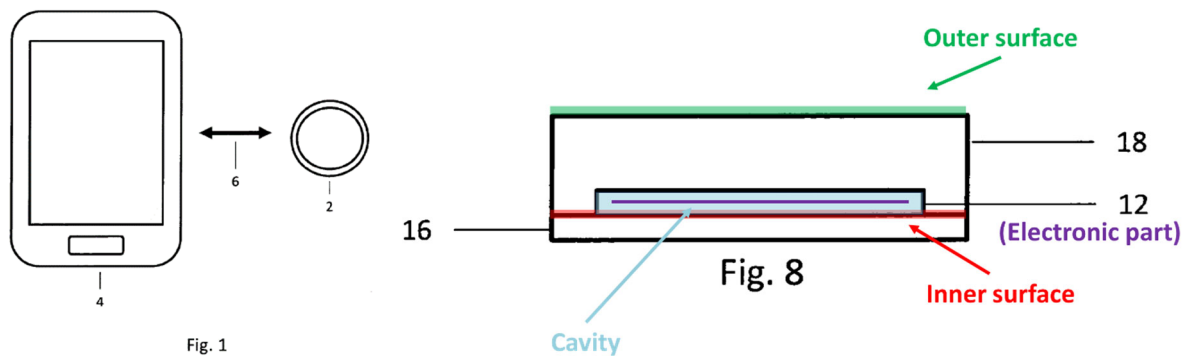
into the user's body" and light detectors (such as photodiodes and/or phototransistors) that "sample, measure and/or detect a response or reflection" from the user's body, which is used by a PPG to determine the user's stress level, blood pressure and/or heart rate. Ex-1006, 6:23-31. The LEDs and photodetectors are provided on a PCB. Ex-1006, 2:38-39 ("the light sources and photodetectors are placed on a flexible PCB"). Yuen further teaches that an optically transparent layer (annotated in yellow) "may be formed through in-mold labeling or 'IML'" on the device's inner surface, covering the unfilled cavity space and electronic part. Ex-1006, 2:44-45. Specifically, Yuen teaches that optically transparent layer may be "placed on the lower surface" to "form a seal" such that it prevents "liquid from entering the device where the light sources or photodetectors are disposed or placed." Ex-1006, 2:39-45.

B. Schröder (U.S. Patent No. 10,303,867) (Ex-1007)

132. 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 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 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 35 U.S.C. §365.

133. Schröder teaches a biometric sensing device, depicted in Figures 1 and 8 below, which is a finger-ring “worn by a user, e.g., permanently on the finger.” Ex-1007, 3:61-63,² Fig. 1 (showing finger-ring 2 communicating with smartphone 4), Fig. 8 (showing cross-sectional view of finger-ring 2).



134. As shown in Figure 8 above, Schröder teaches that a cavity (annotated in blue) is formed on the inner surface of component 18 (annotated in red), which extends to the outer surface of component 18 (annotated in green) of the device. *Id.*,

² Parallel citations to Schröder's German counterpart for all Schröder '867 Patent citations herein are provided in Ex-1022.

Fig. 8. An electronic part such as inlay 12 (annotated in purple) and/or a chip module (not shown) is inserted into or within the cavity of the finger-ring. Ex-1007, 12:10-12 (“The finger-ring 2 consists in principle of at least one component 16, 18 into which at least one inlay 12 is inserted, whereby one component can be a ring half 16, 18.”), 12:26-28 (“The inlay 12 is ... inserted into at least one recess provided therefor within at least one component [].”); *see also id.*, 8:58-59 (a chip module is inserted into the recess). Schröder teaches that the electronic part and the cavity are covered by a coating made of a moldable material such as a low temperature moldable material (e.g., a plastic or resin). Ex-1007, 14:45-46, 15:8-10, 15:14-15. Specifically, Schröder teaches that the finger-ring “can be manufactured by an injection-molding process.” Ex-1007, 14:35-37. The injection-molding process results in “a ring-shaped body in whose interior the chip module 10 and the antenna coil 8 and any further electronic devices are arranged.” Ex-1007, 14:46-49. Schröder additionally teaches that chip module 10 and antenna coil 8 may be “inserted into an injection mold in order to be overmolded.” Ex-1007, 14:50-53.

VII. CLAIM CONSTRUCTION

135. I do not believe that any claim term requires explicit construction to resolve the issues presented in this 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.

136. 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.

VIII. DETAILED EXPLANATION OF THE UNPATENTABILITY GROUNDS

A. Ground 1: Claims 1-11 are obvious over Yuen.

1. Independent Claim 1

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

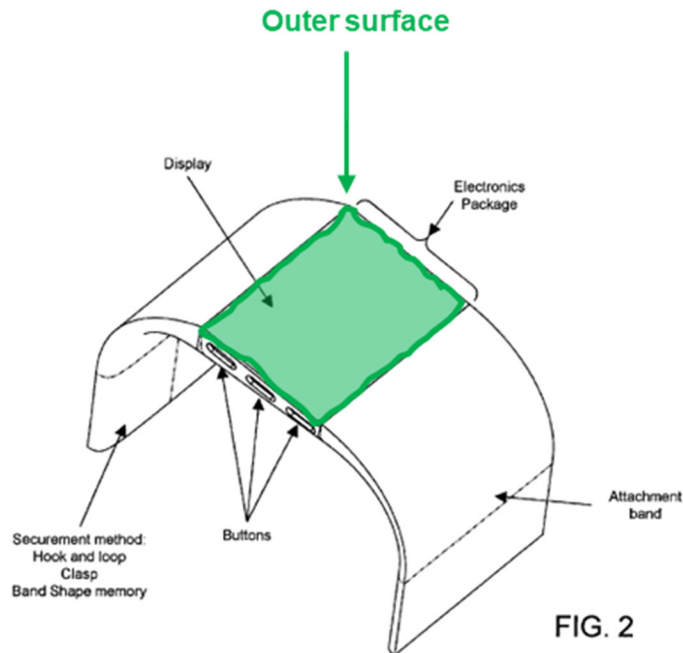
137. Yuen teaches³ the preamble, to the extent it is limiting.⁴

138. Yuen teaches a portable biometric monitoring device, depicted in Figure 2, which 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." Ex-1006, 12:50-52, Fig. 2 (the outer surface of the device annotated in green); *see also id.*, 2:7-17 ("an exemplary portable biometric monitoring device ... may be secured to the user through the use of a band; the exemplary portable biometric monitoring device may have a display, button(s), electronics package, and/or a band or an attachment band; notably, the band or attachment band is employed to secure the portable biometric

³ 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.

⁴ I understand from Counsel that in the *Circular* litigation, where Patent Owner asserted the '833 Patent against an unrelated party, the Court found that the preamble of Claim 1 of the '833 Patent is limiting. *See* Ex-1021, 2.

monitoring device to the user, for example, an appendage of the user”). The 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.

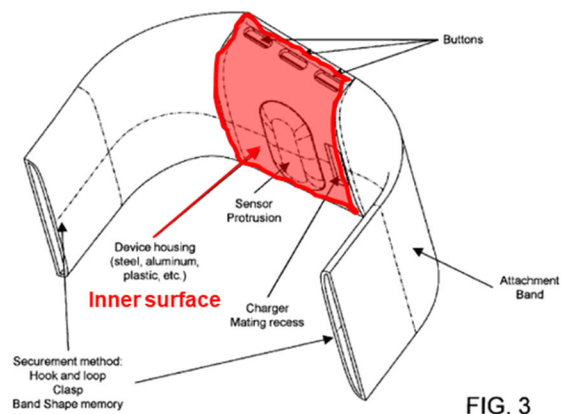
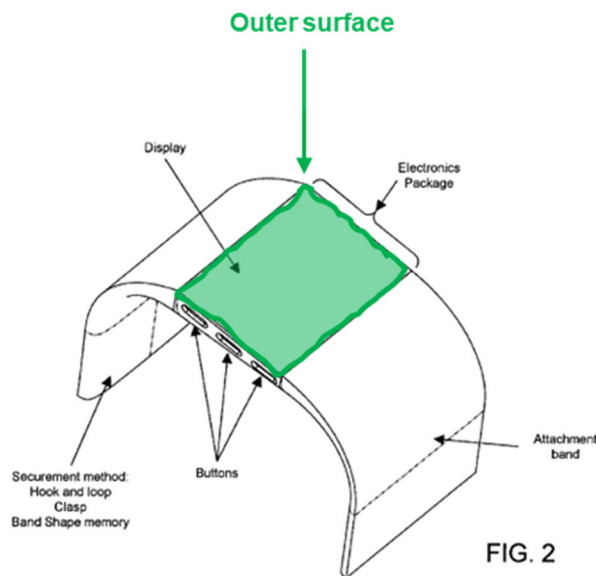


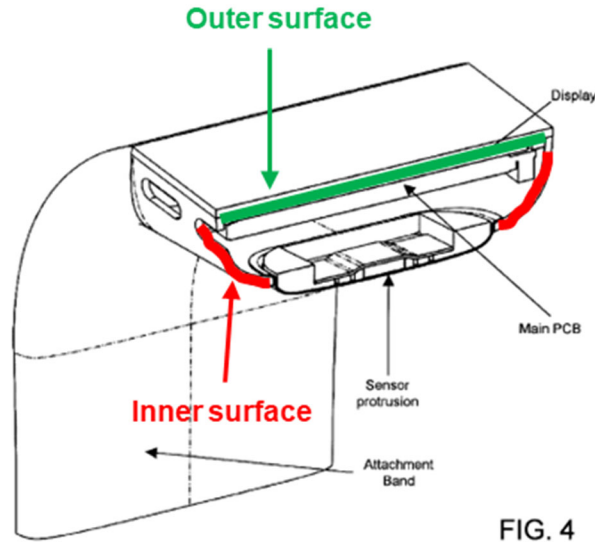
b. Element 1[a]: a body part made of a non-ceramic material,

139. Yuen teaches Element 1[a].

140. 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 outer surface of the biometric monitoring device and Figure 3 depicts the inner surface of the device. Ex-1006, 2:7-11, Fig. 2 (annotated in green), Fig. 3 (annotated

in red). Yuen teaches that “[s]ome or all of the interior or skin side of the housing” for the biometric monitoring device is made of “a metal material” such as, for example, stainless steel, steel, magnesium, aluminum, or titanium. Ex-1006, 14:33-36. 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.” Ex-1006, 14:66-15:4. It would have been well-known to a POSITA by 2013 that a metal or plastic material is a non-ceramic material. *See, e.g.*, Ex-1001, 4:17-20 (“**[N]on-ceramic material, such as plastic, metal** (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).





c. Element 1[b]: having an inner surface and an outer surface,

141. Yuen teaches Element 1[b].

142. As described above, Yuen’s “body” component is the claimed body part, and Yuen’s body part has an inner surface and an outer surface as depicted in Figures 2-4. Specifically, Yuen’s Figure 2 depicts the outer surface (annotated in green) of the biometric monitoring device, which may include, for example, a display. Ex-1006, 2:7-11 (Figure 2’s “exemplary portable biometric monitoring device may have a display, button(s), electronics package, and/or a band or an attachment band”), Fig. 2. Yuen’s Figure 3 depicts the inner “skin facing” surface (annotated in red) of the biometric monitoring device of Figure 2, which may include, for example, the device housing, sensor protrusion, and charger mating recess. Ex-1006, 2:18-22 (“FIG. 3 illustrates a view of the skin facing portion of the portable biometric monitoring device of, for example, FIG. 2; notably, in this

embodiment, the portable biometric monitoring device includes a sensor protrusion and recess for mating a charger and/or data transmission cable”), Fig. 3.

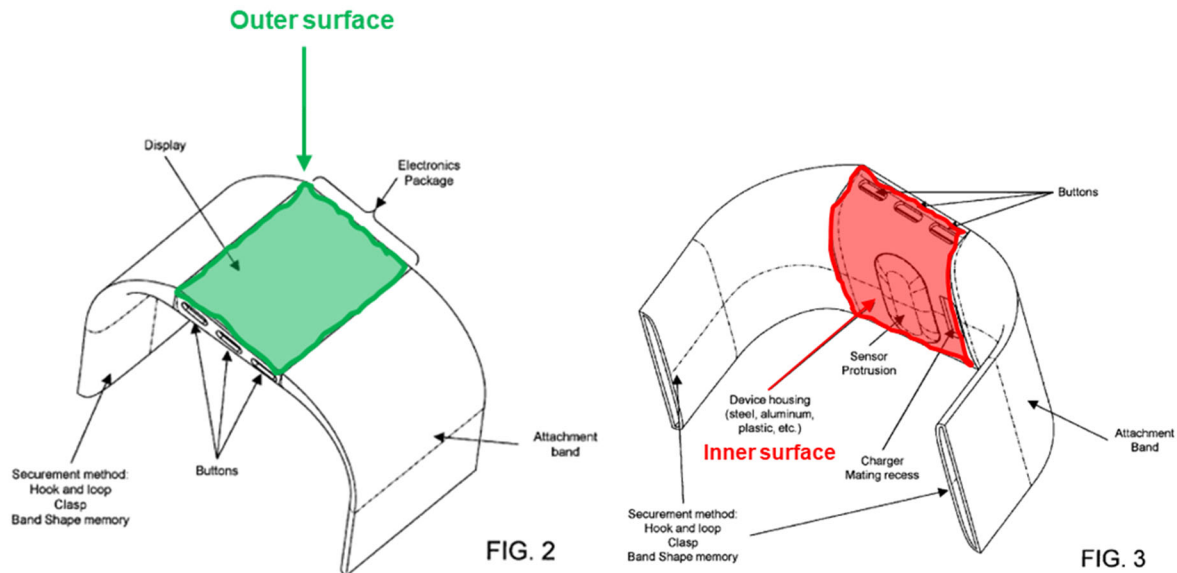
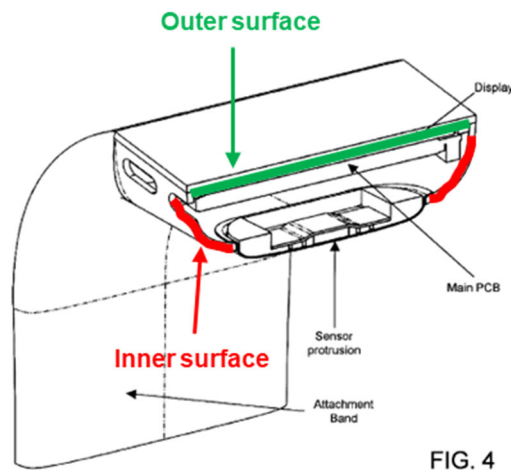


Figure 4 depicts a cross-sectional view of the biometric monitoring device through the electronic part, including the outer and inner surfaces. Ex-1006, 2:26-28, Fig. 4.



143. A POSITA reading “body part” in the ’833 Patent would have understood it as the mechanical structure(s) part of the ring. It (the body part) is the mechanical structure into which the optical and electronics components and parts

are housed and which is used to mechanically constrain/stabilize the optical elements and create the light paths from emitters to body back to detectors. In other words, the body part is the mechanical structure that houses (with mechanical substructures such as walls and cavities) the optical and electronic components. It is designed to mechanically constrain and stabilize the optical elements, ensuring the creation of precise light paths from emitters into the body tissue and through or back to detectors.

144. As I explained in the Technology Background Section (*see* Section V), 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).

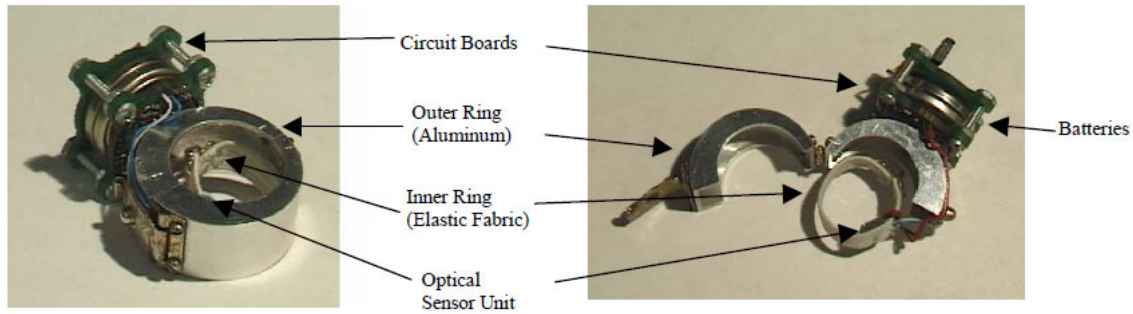


Figure 1 : Isolating ring sensor designed for motion artifact minimization

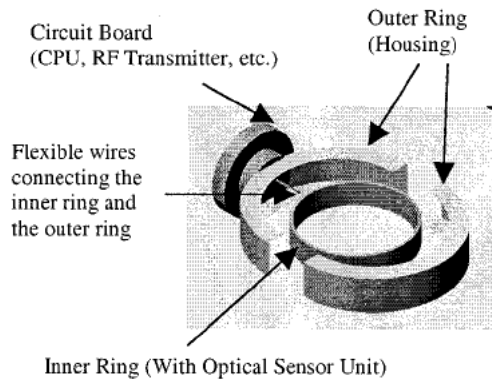
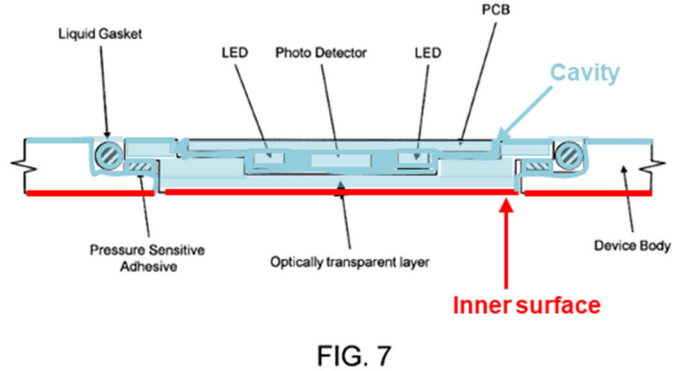
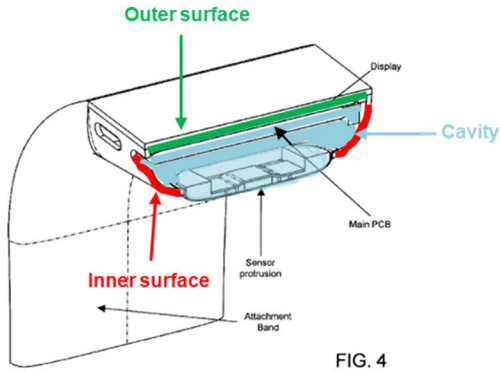


Fig. 3. Construction of isolating ring.

d. Element 1[c]: wherein at least one cavity is formed on the inner surface of the body part,

145. Yuen teaches Element 1[c].

146. Yuen teaches that a cavity is formed on the inner surface of the body part, as depicted in Figures 4 and 7. Ex-1006, Figs. 4, 7. Specifically, Yuen teaches that a cavity is formed on the inner (skin-facing) surface (annotated in 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.



147. In a mechanical structure, a “cavity” refers to a hollow or enclosed space within the structure. This space can be intentionally created for various purposes, such as housing components, reducing weight, or facilitating certain mechanical functions like fluid flow or insulation, or optical function such as guiding light. Cavities are critical in many engineering designs, influencing factors such as structural integrity, weight characteristics, and thermal properties. The area annotated in blue in Figures 4 and 7 is a cavity formed on the inner surface of the device because it is a depression formed in the inner surface of the device and because it is defined in part by the inner surface/wall of the device.

148. As I explained in the Technology Background Section (*see* Section V), by 2013, the formation of cavities, whether by single-structure formation or multi-structure assembly techniques, was known to be essential for integrating electronic components, optical components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This was known to be 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 were known to vary based on tooling sizes, costs, and complexities.

149. 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.

150. 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 and were widely known as of 2013. 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 and were known in 2013. 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 and were also known by 2013.

151. 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.

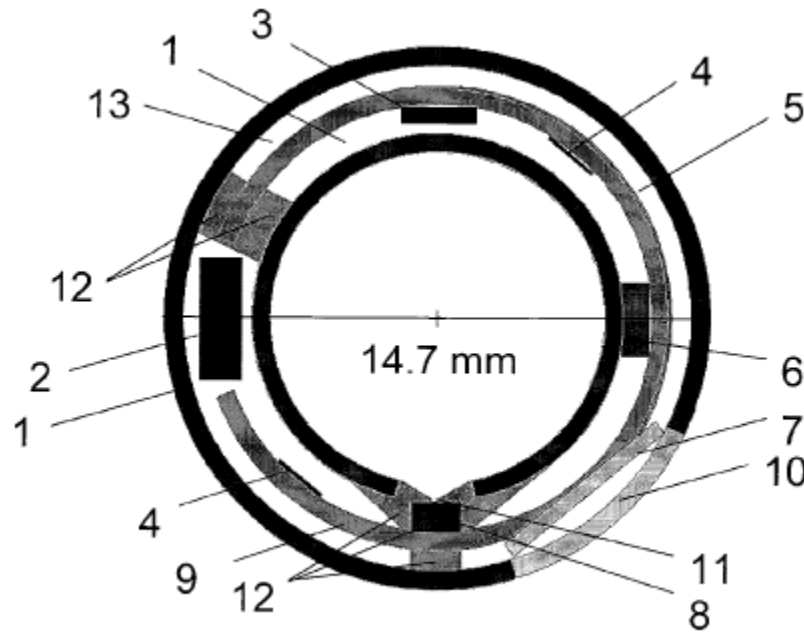


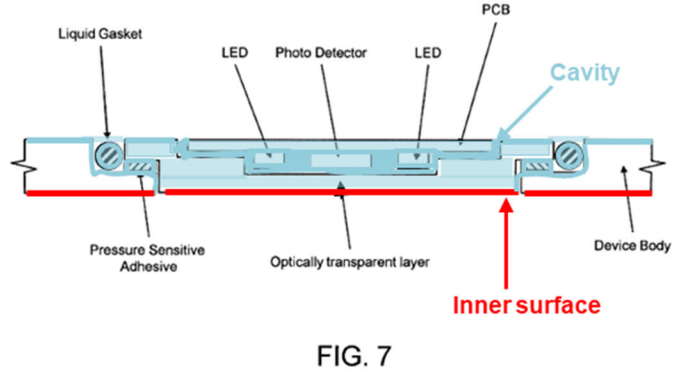
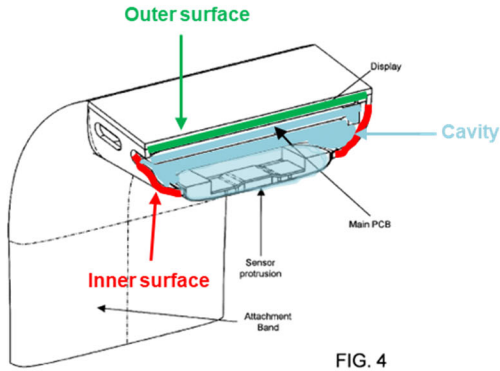
Fig. 1

152. 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.

- e. **Element 1[d]: the at least one cavity extending from the inner surface of the body part towards the outer surface of the body part and having a depth arranged within the inner surface of the body part,**

153. Yuen teaches Element 1[d].

154. Yuen teaches that the cavity (annotated in blue), which houses the electronic part including the LEDs and photodetector, extends from the inner (skin-facing) surface of the biometric monitoring device (annotated in red) towards the outer surface of the device (annotated in green), as shown in Figures 4 and 7. Ex-1006, Figs. 4, 7 (outer surface not shown).



155. Yuen teaches that the cavity extending from the inner surface towards the outer surface of the device has a depth arranged within the inner surface because the cavity is contained entirely within the inner surface of the device, as shown in the cross section of Figure 7. Moreover, the cavity is designed to include electronic components, which are 3-dimensional objects that themselves have a certain length, width, and depth. *See, e.g.,* Ex-1006, 12:35-45 (“[T]he light source(s) and/or associated detector(s) are disposed on a Flat Flex Cable or ‘FFC’ or flexible PCB. ... Optical components of differing heights may be mounted to different ‘fingers’ of flexible substrate and pressed or secured to the housing surface such that the optical components are flush to the housing surface.”). Since the cavity must be large enough to house physical electronic components that have a certain depth, the cavity must also have a corresponding greater depth (i.e., the vertical thickness of the cavity (annotated in blue) in Figures 4 and 7). A POSITA would have recognized that the cavity, which extends from the inner surface toward the outer surface of the device, is designed with a depth that is specifically arranged within the boundaries of the

inner surface. This implies that the entirety of the cavity is enclosed within the surfaces of the device, meaning that the cavity does not breach the surfaces and remains completely contained within the interior limits set by the encompassing surfaces. This arrangement is crucial for maintaining the structural integrity of body while allowing for specific functionalities or component housing within the inner portions of the device.

156. As I explained in the Technology Background Section (*see* Section V), by 2013, the formation of cavities, whether by single-structure formation or multi-structure assembly techniques, was known to be essential for integrating electronic components, optical components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This was known to be 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 were known to vary based on tooling sizes, costs, and complexities.

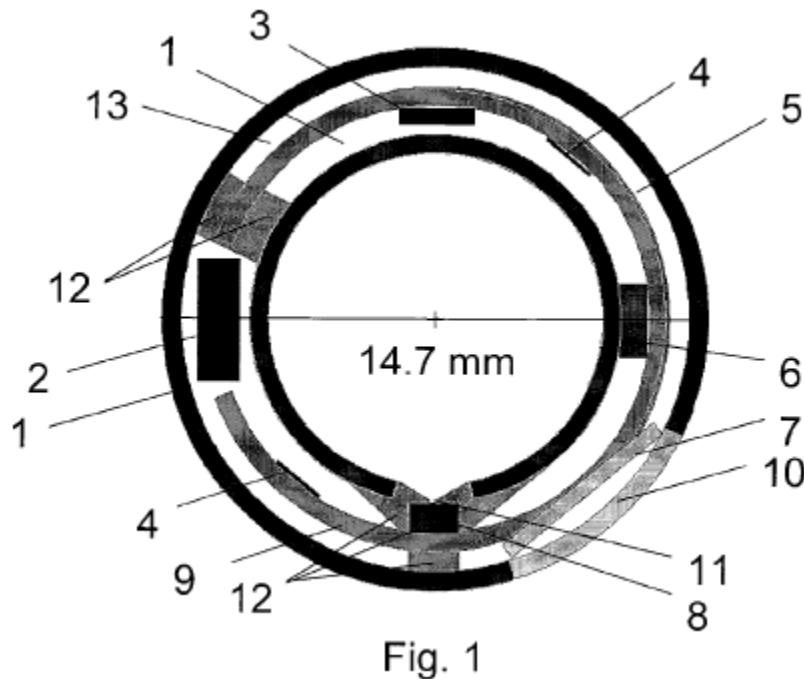
157. Most objects seen in everyday life are non-planar. Therefore, it is necessary that the electronic systems fit a convenient form factor of the shape into which it will be integrated.

158. 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 and were widely known as of 2013. 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 and were known in 2013. 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 and were also known by 2013.

159. 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.



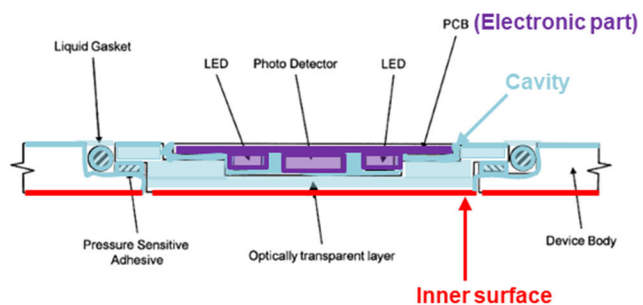
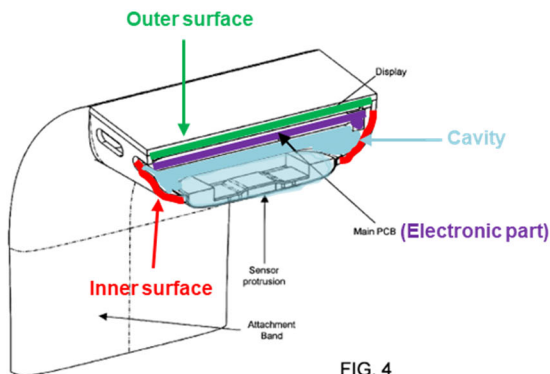
160. Similarly, U.S. Patent No. 6,201,698 to Hunter teaches that “the side

walls and the web together create a cavity [] to house the electronic circuit.” Ex-1060, 2:56-57.

f. Element 1[e]: an electronic part arranged in said at least one cavity,

161. Yuen teaches Element 1[e].

162. Yuen teaches that the biometric monitoring device includes “two major components”, one being the “body (containing the ‘electronics’)” and the other being the “band (that facilitates attaching the device to the user).” Ex-1006, 24:14-17. As depicted in Figures 4 and 7, the electronic part (annotated in purple) is arranged in the cavity (annotated in blue). Ex-1006, Figs. 4, 7.



163. The electronic part housed in Yuen’s cavity includes, for example, “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 to determine the user’s stress level, blood pressure and/or heart rate. Ex-1006, 6:23-31. The LEDs and photodetectors may be provided on a

flexible printed circuit board (“PCB”). Ex-1006, 2:38-39 (“the light sources and photodetector are placed on a flexible PCB”).

164. As I explained in the Technology Background Section (*see* Section V), by 2013, the formation of cavities, whether by single-structure formation or multi-structure assembly techniques, was known to be essential for integrating electronic components, optical components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This was known to be 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 were known to vary based on tooling sizes, costs, and complexities.

165. 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.

166. 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 and were widely known as of 2013. 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 and were known in 2013. 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 and were also known by 2013.

167. 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 was common as of 2013.

168. 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).

169. 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.

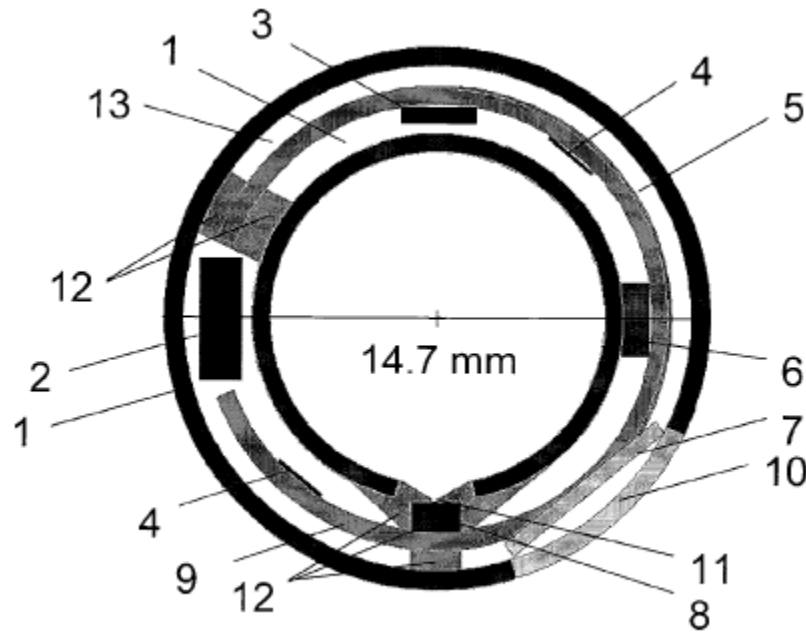


Fig. 1

170. 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.

171. 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.

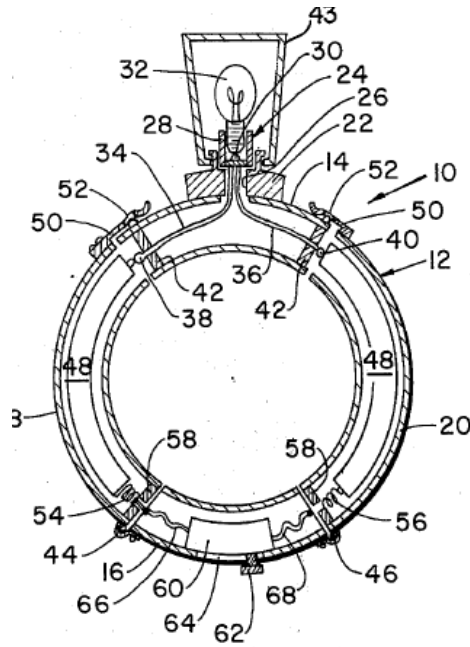


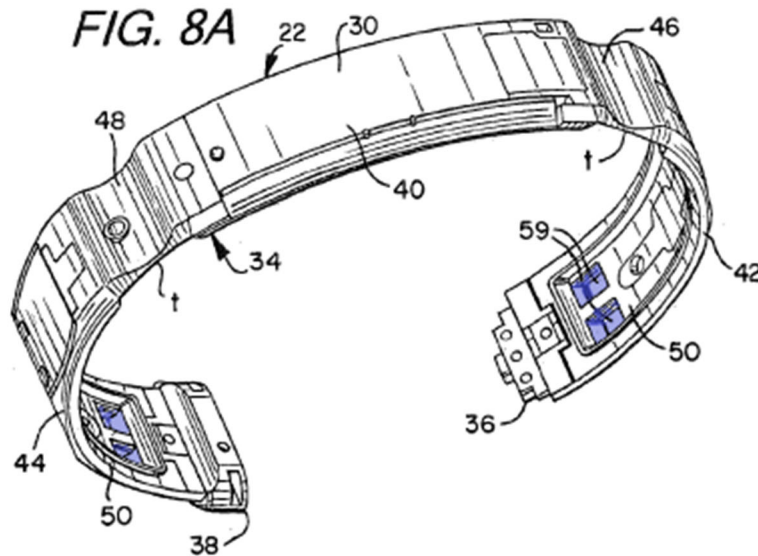
FIG. 2

172. Moreover, U.S. Patent Publication No. 20140244009 to Mestas teaches an electronic wearable device that has “compartments” for its electronic components. Mestas’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.



173. Encapsulating electronics within a cavity of a structural element, for example, injection molding or potting, was well known by 2013. *See, e.g.,* Ex-1055, Ex-1056, Ex-1057, Ex-1058, and Ex-1059.

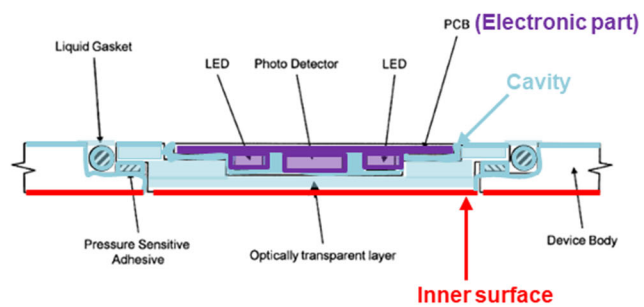
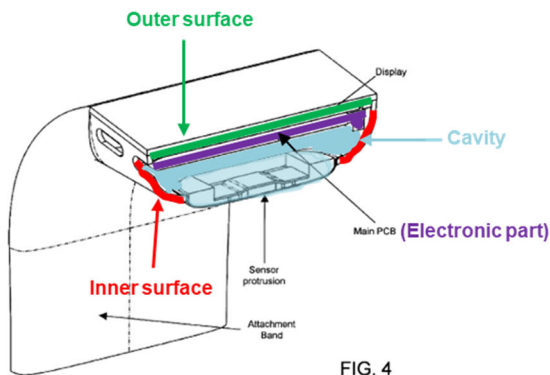
174. Housing electronic parts within one component or between two components was known. For example, U.S. Patent No. 6,699,199 to Asada teaches that “one or more photo diodes 2 and one or more light-emitting diodes (LEDs) 4

are imbedded in a ring 10.” Ex-1034, 2:59-61 (Asada ’199). Moreover, U.S. Patent No. 6,745,061 to Hicks patent 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).

g. Element 1[f]: which electronic part has a thickness that is less than the depth of the at least one cavity, and

175. Yuen teaches Element 1[f].

176. Yuen teaches that the electronic part (annotated in purple) has a thickness that is less than the depth of the cavity (annotated in blue), as depicted in Figures 4 and 7. Ex-1006, Figs. 4, 7.



177. A POSITA would have understood that the electronic part, including the LEDs and photodetector attached to a PCB, has a thickness less than the depth of the cavity because the electronic part must fit within the depth of the cavity to

maintain the intended structural and functional integrity of the device. Additionally, Yuen teaches at least one embodiment wherein the electronic part is “disposed or placed flush to the surface of the device.” Ex-1006, 14:59-66. A POSITA would have understood that the electronic part would have to have a thickness less than the depth of the cavity to be disposed or placed flush to the surface of the device.

178. A POSITA would have understood that the electronic part, which comprises LEDs and a photodetector mounted on a printed circuit board (PCB), is designed with a thickness that does not exceed the depth of the cavity within the device. This understanding implies that the thickness of the electronic part is specifically tailored to be less than or equal to the depth of the cavity, ensuring that it fits entirely within the confines of this space. This design consideration is critical as it prevents the electronic components from protruding beyond the cavity, thus maintaining the intended structural and functional integrity of the device. This arrangement facilitates integration of the electronic components, while safeguarding its compact and contained design.

179. As I explained in the Technology Background Section (*see* Section V), by 2013, 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 patent 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).

180. Encapsulating electronics within a cavity of a structural element, for example, injection molding or potting, was well known by 2013. *See, e.g.*, Ex-1055, Ex-1056, Ex-1057, Ex-1058, and Ex-1059.

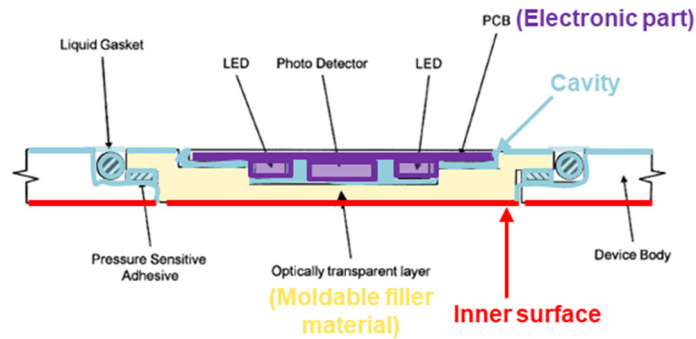
h. Element 1[g]: a coating made of a moldable filler material on the inner surface of the body part, covering the electronic part and the at least one cavity.

181. Yuen teaches Element 1[g].

182. The '833 Patent teaches that the moldable filler material “is filled in the cavity embedded with the electronic part” such that it “sealingly covers” the “electronic part and fills the remaining space of the cavity arranged on the inner surface of the molded body part.” Ex-1001, 5:46-54. The '833 Patent further teaches that the moldable filler material may comprise, for example, an epoxy material or an ink. *See, e.g.*, Ex-1001, 5:55-6:11.

183. As depicted in Figure 7, Yuen teaches an optically transparent layer (annotated in yellow) on the inner surface of the device (annotated in red) that covers the electronic part (annotated in purple) and the cavity (annotated in blue). Ex-1006,

Fig. 7.



Yuen teaches that the optically transparent layer “may be formed through in-mold labeling or ‘IML’” and “placed on the lower surface” to “form a seal” such that it prevents “liquid from entering the device where the light sources or photodetectors are disposed or placed.” Ex-1006, 2:39-45. Yuen further teaches that the moldable filler material may comprise an epoxy or an ink. Ex-1006, 10:63-11:1, 14:52-55. For example, Yuen teaches that the biometric monitoring device may use an IML “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, 11:21-33. The light transmissive structure may be created by “a double-shot or two step molding process wherein optically opaque material is injected and optically transparent material is injected.” Ex-1006, 11:33-36.

184. A POSITA would have understood that Yuen’s optically transparent layer, which is formed by injection from moldable material having transparent and

opaque portions, is a coating made of a moldable filler material that covers the electronic part and cavity on the inner surface of the device, as claimed. This is consistent with the '833 Patent's teachings on a moldable filler material. Ex-1001, 5:46-6:11. A POSITA would have understood that Yuen's molding material is a "moldable filler material" that fills in the cavity and encapsulates the electronic part within.

185. As I explained in the Technology Background Section (*see* Section V), using a moldable filler 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.

186. 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.

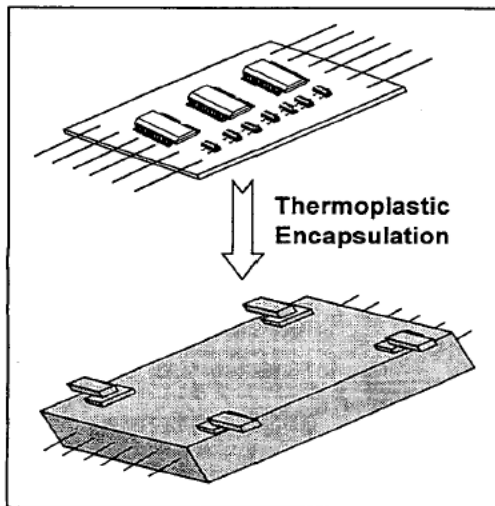


Figure 1. Illustration of the electronic overmoulding

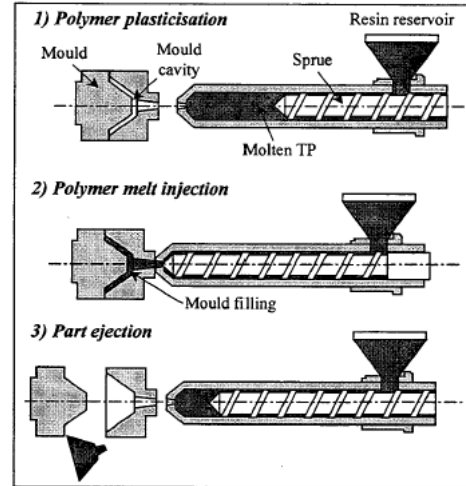


Figure 2. Schematic diagram of injection moulding

187. 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). 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 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.”).

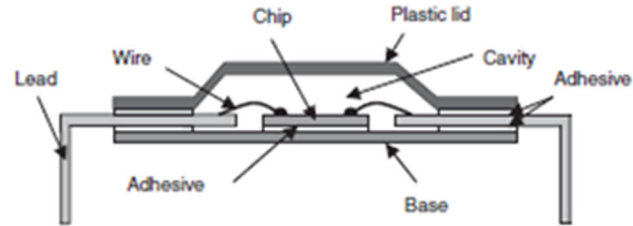


Figure 1.5 A pre-molded plastic package [9].

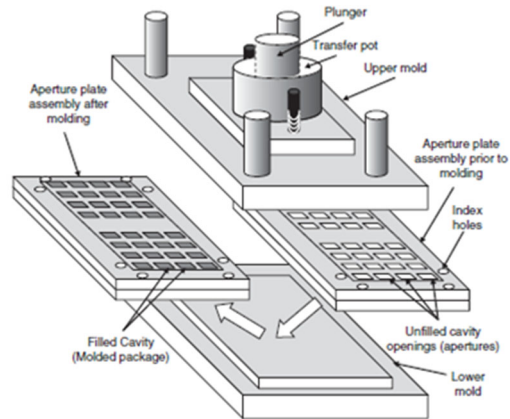


Figure 3.4 Aperture-plate (or cavity plate) molding setup [3].

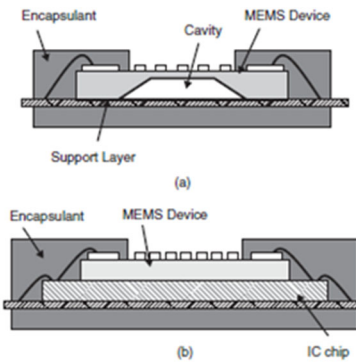


Figure 8.12 Plastic-encapsulated MEMS device package designs from Industrial Technology Research Institute: (a) MEMS device with a cavity; (b) 3D package with a MEMS device stacked on an IC chip [21].

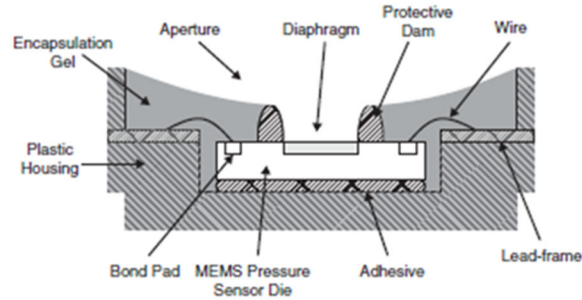


Figure 8.13 Plastic-encapsulated MEMS pressure sensor device from Motorola [22].

188. 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.”).

189. 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”).

190. Yuen uses a moldable filler material 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.

191. Yuen further emphasizes the importance of having a watertight seal of the device. *See, e.g., id.*, 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.

2. Dependent Claims 2-11

a. Claim 2: The wearable electronic device according to claim 1, wherein the non-ceramic material is a titanium material.

192. Yuen teaches Claim 2.

193. Yuen teaches that “[s]ome or all of the interior or skin side of the housing” for the biometric monitoring device is made of “a metal material (for example, steel, stainless steel, aluminum, magnesium, or *titanium*).” Ex-1006,

14:33-36. 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.” Ex-1006, 14:66-15:4. Titanium is a non-ceramic material. *See, e.g.,* Ex-1001, 4:17-20 (“*[N]on-ceramic material, such as plastic, metal* (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

b. Claim 3: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable material.

194. Yuen teaches Claim 3.

195. Yuen teaches that “[s]ome or all of the interior or skin side of the housing” for the biometric monitoring device is made of “a metal material (for example, steel, stainless steel, aluminum, magnesium, or titanium).” Ex-1006, 14:33-36. 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.” Ex-1006, 14:66-15:4. A metal material is a non-ceramic material. *See, e.g.,* Ex-1001, 4:17-20 (“*[N]on-ceramic material, such as plastic, metal* (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

196. A POSITA would have understood that the metal materials taught by Yuen are machinable. As I explained in the Technology Background Section (*see* Section V), 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 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).

197. Moreover, a POSITA would have understood that using a machinable metal material in Yuen’s biometric monitoring device such as a metal alloy would have been both obvious and preferable over other materials because a machinable metal material would have, for example, better corrosion or abrasion resistance, lower cost, higher strength, weight, rigidity, and desirable manufacturing workability. A POSITA would have considered metal among the material selection options for a design when evaluating design-choice trade-offs between select

properties and in order to achieve desired product specification, manufacturability, and cost goals.

c. Claim 4: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable titanium material.

198. Yuen teaches Claim 4.

199. Yuen teaches that “[s]ome or all of the interior or skin side of the housing” for the biometric monitoring device is made of “a metal material (for example, steel, stainless steel, aluminum, magnesium, or *titanium*).” Ex-1006, 14:33-36. 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.” Ex-1006, 14:66-15:4.

200. A POSITA would have understood that titanium is a machinable material. As I explained in the Technology Background Section (*see* Section V), 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

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).

201. Moreover, a POSITA would have understood that using a machinable titanium material such as a titanium alloy in Yuen’s biometric monitoring device would have been both obvious and preferable over other materials because a machinable titanium material would have, for example, better corrosion and abrasion resistance, higher strength (and strength to weight ratio), and better appearance. Moreover, a machinable titanium material is a non-ceramic material. *See, e.g.*, Ex-1001, 4:17-20 (“**[N]on-ceramic material, such as plastic, metal** (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

- d. Claim 5: The wearable device according to claim 1 wherein the non-ceramic material is a machinable metallic material comprising one or more of titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys.**

202. Yuen teaches Claim 5.

203. Yuen teaches that “[s]ome or all of the interior or skin side of the housing” for the biometric monitoring device is made of “a metal material (for

example, *steel*, *stainless steel*, aluminum, magnesium, or *titanium*)." Ex-1006, 14:33-36. 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." Ex-1006, 14:66-15:4.

204. A POSITA would have understood that the metallic materials taught by Yuen are machinable. As I explained in the Technology Background Section (*see* Section V), 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 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).

205. A POSITA would have further understood that using a machinable metallic material such as a titanium or steel alloy would have been both obvious and

preferable over other material for the same reasons discussed in Sections VIII.A.2.b-VIII.A.2.c, namely, because a machinable metallic material would have for example, better corrosion resistance, lower cost, higher strength, and better workability. A POSITA would have considered metal among the material selection options for a design when evaluating design-choice trade-offs between select properties and in order to achieve desired product specification, manufacturability, and cost goals.

- e. **Claim 6: The wearable electronic device according to claim 1, wherein the electronic part is attached to the [at least one] cavity [at] a bottom of the [at least one] cavity.⁵**

206. Yuen teaches Claim 6.

207. A POSITA would have understood that the bottom of the cavity is the side of the cavity that is away from the inner (skin-side) surface of the device. Figure 7C of the '833 Patent, depicted below, is consistent with this understanding, as it shows the electronic part 314 (annotated in purple) attached to the end of the cavity (annotated in blue) away from the inner (skin-side) surface 110 (annotated in red) of the device. Ex-1001, Fig. 7C.

⁵ I understand that in the *Circular* litigation, where Patent Owner asserted the '833 Patent against an unrelated party, Patent Owner argued and the Court stated that Claim 6 is not indefinite and should read “the at least one cavity at a bottom of the at least one cavity.” See Ex-1021, 2. For purposes of this Petition only, I adopt the Court’s construction of Claim 6 from the *Circular litigation*, but by doing so, I do not intend to, and do not, waive any argument that Claim 6 is indefinite in any future district court litigation against PO.

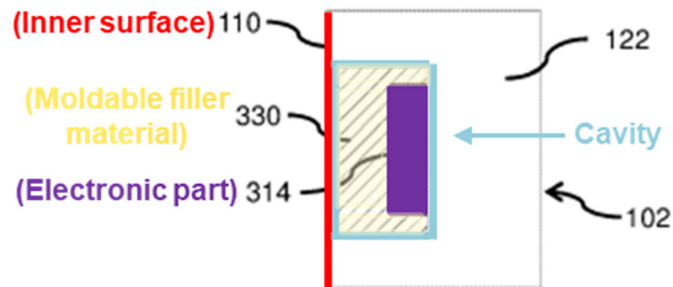
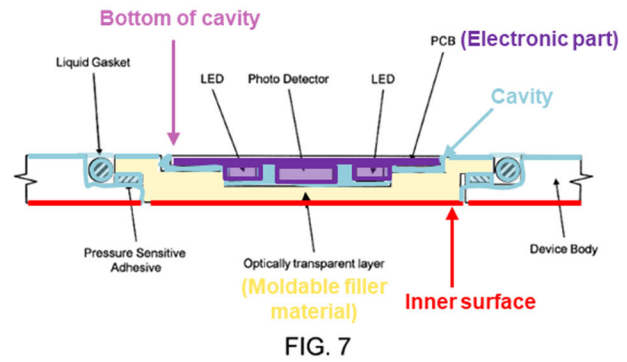
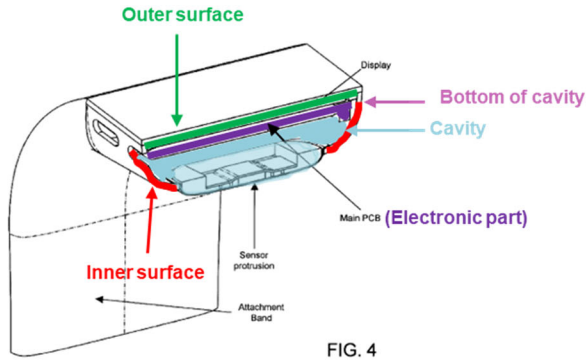


FIG. 7C

208. Yuen teaches that the electronic part (i.e., the main PCB and any LEDs and/or photodetectors positioned on it (Ex-1006, 2:38-39)) is attached to the bottom of the cavity, i.e., away from the inner (skin-side) surface of the biometric monitoring device. Yuen’s optical sensors including the LEDs and photodetector are positioned “on an interior or skin side of the biometric monitoring device (i.e., a side whereby the surface of the device contacts, touches and/or faces the skin of the user (hereinafter ‘skin side’).” Ex-1006, 9:57-61; *see also id.*, 12:55-61 (“In one embodiment, optical elements of the optical heart rate monitor are disposed or located on the interior or skin side of the biometric monitoring device, for example, facing the top of the wrist (i.e. the optical heart rate monitor is juxtaposed the wrist) when the device is wrist mounted.”). The LEDs/photodetector are further positioned “on a flexible or pliable substrate,” such as a flexible PCB, which allows the inner surface of the device to adapt to the shape of the user’s appendage (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 ("In one embodiment, the 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.")). Yuen teaches that "optical components of differing heights may be mounted to different 'fingers'" of the flexible PCB "and pressed or secured to the housing surface such that the optical components are flush to the housing surface." Ex-1006, 12:42-45.

209. A POSITA would have understood, as depicted in Yuen's Figures 4 and 7, that the electronic part (annotated in purple) is attached to the cavity (annotated in blue) at the bottom of the cavity, i.e., away from the inner surface. Ex-1006, Figs. 4 (depicting a cross-sectional "through the electronics package" (PCB)), 7 (depicting a cross-sectional view of the PPG sensor with the LEDs and photodetector positioned on the PCB). For example, Figure 4 shows that the main PCB is located and attached to the base (bottom) portion of the cavity (blue). Figure 7 shows that the main PCB (including the LEDs and photodetector positioned on it) are located and attached to the base (bottom) portion of the cavity (blue).



A POSITA would have understood that it would have been beneficial to have the electronic part attached to the bottom of the cavity for a number of reasons including because it would provide a higher mechanical rigidity reducing the likelihood for relative motion between the body part and electronic part, less variable sensor reading, reduction of noise at least because of decreased pathways for “stray” light, vibration tolerance, damage protection for the device, and simplifying manufacturing assembly. Electronic devices including wearable electronic devices are vulnerable to shock, damage, and vibrations, for example, if they are dropped or hit against hard surfaces. Attaching the electronic part to the bottom of the cavity of the device would have been an obvious design choice to mitigate extreme vibrations and damage to the device, and to simplify, reduce variation, improve quality, reduce time of overall manufacturing assembly.

210. As I explained in the Technology Background Section (*see* Section V), 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

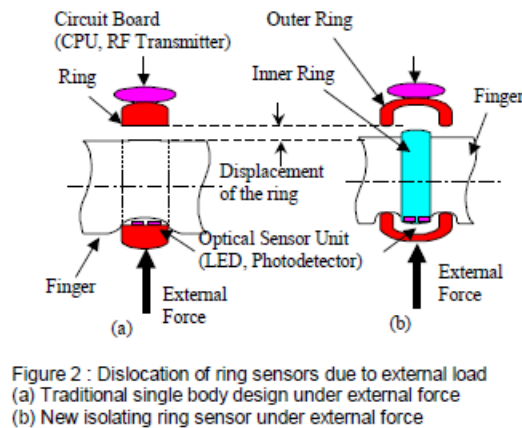
example, the Konig reference teaches that, in transmission pulse oximetry “[t]he optical elements are located on the opposite sides of a body part” and “[t]he sensors are applied mainly to the fingers and toes.” Ex-1027, 405 (Konig).

211. 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).

212. 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).



213. 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).”).

f. Claim 7: The wearable electronic device according to claim 6, comprising one or more of a sticker, a tape or glue that attaches the electronic part to the at least one cavity at a bottom of the at least one cavity.

214. Yuen teaches Claim 7.

215. Yuen teaches that the electronic part is attached to the bottom of the cavity, i.e., away from the inner (skin-side) surface of the biometric monitoring device for the same reasons discussed in the previous section. Yuen also teaches that the optical sensor components—which may be disposed flush to the skin-side surface of the device—are fixed, attached, secured to and/or included in the biometric monitoring device “via a liquid-tight seal (i.e., a method/mechanism that prevents liquid ingress into the body of the biometric monitoring device).” Ex-1006, 14:59-66. Yuen further teaches, citing Figure 7, that “a package or module of the optical sensor would be connected to the device with a pressure sensitive adhesive and a liquid gasket.” Ex-1006, 15:5-7, Fig. 7 (annotated in pink).

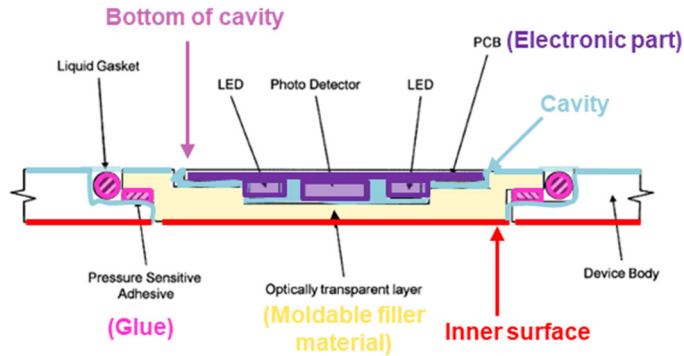
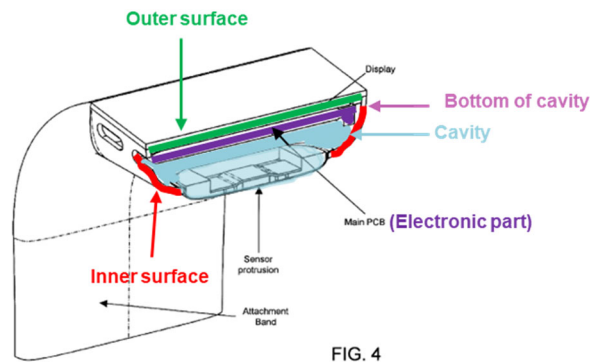


FIG. 7

Yuen's optical sensor components may be attached or secured to the body of the device using, for example, "watertight glues, hydrophobic membranes such as Gore-Tex, O-rings, sealant, grease, or epoxy." Ex-1006, 15:10-14. As Figure 7 illustrates, the pressure sensitive adhesive (such as glue) attaches the electronic part to the cavity at the bottom of the cavity, as claimed, via an attachment structure in the molded body part. This is consistent with the '833 Patent's teachings as to how the electronic part is attached to the bottom of the cavity. *See, e.g.*, Ex-1001, 5:14-18 ("[T]he electronic part is attached to the cavity by an attachment means arranged at a bottom of the cavity. The attachment means is selected from a group consisting of a sticker, a tape, glue, and an attachment structure made in the molded body part."). A POSITA would thus have understood that the electronic part is attached to the device body at the bottom of the cavity with an adhesive (such as glue).

216. Additionally, as explained in the previous section, Figure 4 shows that the main PCB is located and attached to the base (bottom) portion of the cavity (annotated in blue). Ex-1006, Fig. 4. It would have been obvious to a POSITA that

an adhesive (such as glue) would also be used to attach the main PCB to the bottom of the cavity in Figure 7, as demonstrated in Figure 4. Such attachment methods ensure the stability and secure placement of the electronic component within the device. The use of adhesives is a common and effective approach in electronics manufacturing assembly, providing a reliable and cost-effective means of securing components in place. The integration of such techniques in device manufacturing is critical for maintaining the integrity and functionality of the final product.



- g. **Claim 8: The wearable electronic device according to claim 1, wherein the moldable filler material is selected from a group consisting of at least epoxy material, Polyethylene, Polyurethane, low temperature moldable material, Loctite M-31CL, alpha-epoxy, 1,2-epoxy, EpoxAcast® 650, Bisphenol S epoxy resin, Novolac epoxy resin, Aliphatic epoxy resin and Glycidylamine epoxy resin.**

217. Yuen teaches Claim 8.

218. Yuen teaches that the moldable filler material on the inner surface of the device covering the electronic part and the cavity consists of at least epoxy material. Specifically, as depicted in Figure 7, Yuen teaches an optical transparent

layer (annotated in yellow), which “may be formed through in-mold labeling or ‘IML.’” Ex-1006, 2:44-45, Fig. 7. Yuen further teaches that other sensors in addition to or instead of a heart rate sensor may be provided in “close proximity and/or secure contact to the user’s skin,” including, for example, “a skin temperature sensor (e.g., noncontact thermopile that utilizes the optical window or thermistor joined with *thermal epoxy* to the outer surface of the protrusion).” Ex-1006, 13:62-14:3. Specifically, Yuen teaches that the “skin temperature *sensor may be physically and thermally coupled*, for example *with thermal epoxy, to the metal body* to detect or sense the temperature of the user.” Ex-1006, 14:52-55.

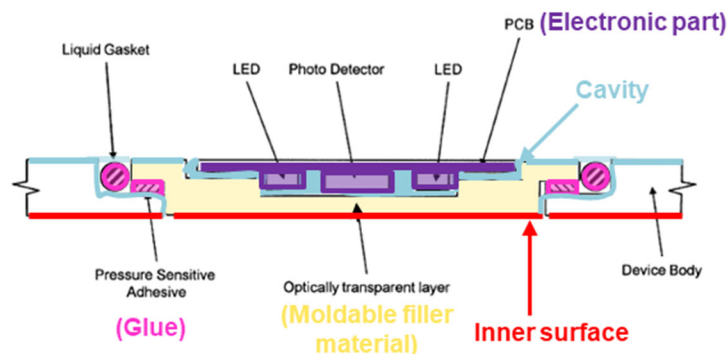


FIG. 7

219. A POSITA would thus have understood that the optically transparent layer, which is a coating made of moldable filler material on the inner surface of the device covering the electronic part and the cavity, may be epoxy material, and that there is a benefit and function related to and including mechanical (structural), thermal, and optical properties provided by the filler which a POSITA would have chosen and known how to use in various design choices and for different device

configurations.

220. As I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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 flexible layer made up of a material similar to the clear substrate 80 and is utilized for its light blocking characteristics.”).

221. 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 is toleranced 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 carried 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.").

- h. Claim 9: The wearable electronic device according to claim 1, wherein the electronic part comprises one or more of a battery, an infrared transmitter, a microcontroller, a radio frequency transceiver, a temperature sensor and an infrared receiver.**

222. Yuen teaches Claim 9.

223. Yuen's electronic part may include a temperature sensor. Specifically, Yuen teaches that a "skin temperature sensor may be physically and thermally coupled, for example with thermal epoxy, to the metal body to detect or sense the temperature of the user." Ex-1006, 14:52-55; *see also id.*, 7:52-58, 13:62-14:3.

224. Yuen's electronic part may include a microcontroller. Specifically, Yuen teaches that the biometric monitoring device comprises at least one processor including, for example, at least one application processor and at least one sensor processor. Ex-1006, 22:60-23:6; *see also id.*, 23:26-29. Yuen's Figure 17 depicts an exemplary PPG sensor that includes "a light source, light detector, ADC, processor, DAC/GPIOs, and light source intensity and on/off control." Ex-1006, 4:3-6, Fig. 17.

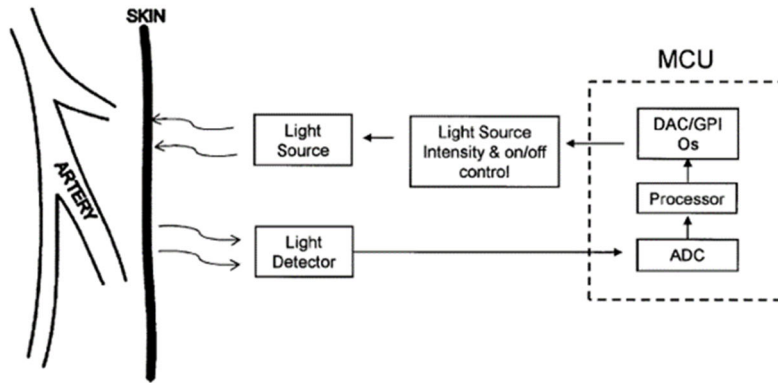


FIG. 17

Yuen additionally teaches that the main PCB may have electronics “such as, but not limited to, transimpedance amplifiers, filtering circuits, level shifters, sample and hold circuits, and a microcontroller unit.” Ex-1006, 23:7-20.

225. Yuen’s electronic part may include a battery. Specifically, Yuen teaches that the biometric monitoring device may include “a rechargeable energy source” such as a rechargeable battery, which interconnects “with a charger using magnetic properties to secure thereto.” Ex-1006, 14:42-46. For example, the device “may use a wired connection to charge an internal rechargeable battery and/or transfer data to a host device such as a laptop or mobile phone.” Ex-1006, 28:40-43.

226. As I explained in the Technology Background Section (*see* Section V), it was known by 2013 that 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).

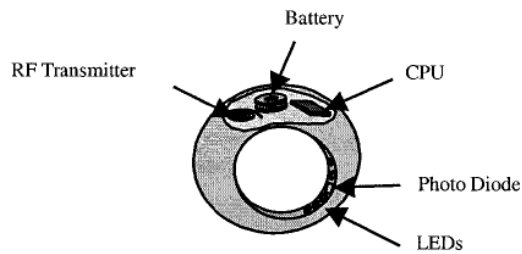


Fig. 1. Conceptual diagram of the ring sensor.

227. 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 module 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.”).

- i. **Claim 10: The wearable electronic device according to claim 9, wherein the moldable filler material comprises an ink and is configured to cover at least an area other than the infrared transmitter and the infrared receiver within the at least one cavity.**

228. Yuen teaches Claim 10.

229. Yuen teaches that the moldable filler material comprises an ink and covers an area between the optical components and the inner (skin-side) surface of the cavity. Specifically, as depicted in Figure 7, Yuen teaches an optical transparent layer (annotated in yellow), which “may be formed through in-mold labeling or ‘IML.’” Ex-1006, 2:44-45, Fig. 7. Yuen teaches that the biometric monitoring device may include a material placed on the inner (skin-side) surface that “includes high reflectivity characteristic—for example, polished stainless steel, *reflective paint*, and polished plastic,” which allows light to be scattered and/or reflected “off the skin side of the device ... back into the skin.” Ex-1006, 15:15-21. Yuen teaches that this material improves SNR by effectively increasing “the input light signal” as compared to a non-reflective device surface. Ex-1006, 15:21-23. Yuen further teaches that “the circuitry related to emitting and receiving light may be *disposed in the interior of the device housing* and underneath a plastic or glass layer (for example, *painted with infrared ink*) or an infrared lens which permits infrared light to pass but not light in the human visual spectrum.” Ex-1006, 10:63-11:1.

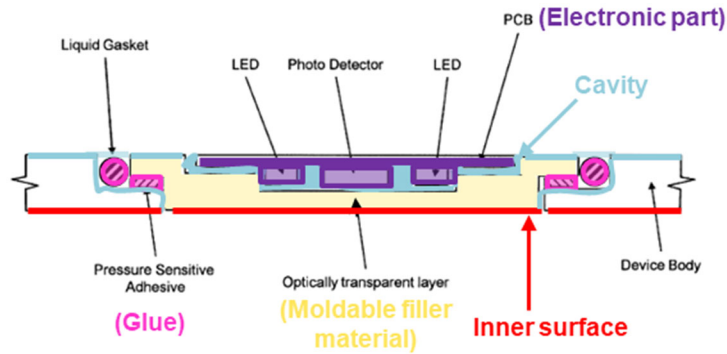


FIG. 7

230. A POSITA would have understood that the infrared ink taught by Yuen would be applied to the optically transparent layer (annotated in yellow) within the cavity (annotated in blue), as depicted in Figure 7, where it is shown to cover at least an area other than that corresponding to the LEDs and the photodetector in order to obtain beneficial optical properties relating to blocking or some wavelength and transmission of some wavelengths.

231. As I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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.”).

232. 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 is toleranced 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 carried 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.”).

- j. **Claim 11: The wearable electronic device according to claim 1, wherein the moldable filler material comprises an ink that increases a value of transmitted infrared light intensity divided by transmitted visible light intensity.**

233. Yuen teaches Claim 11.

234. Yuen teaches that the moldable filler material comprises an ink that allows preferential transmission of infrared light such that the ink increases a value of transmitted infrared light intensity divided by transmitted visible light intensity. In particular, Yuen teaches that “the circuitry related to emitting and receiving light may be disposed in the interior of the device housing and underneath a plastic or glass layer (for example, *painted with infrared ink*) or an infrared lens *which permits infrared light to pass but not light in the human visual spectrum.*” Ex-

1006, 10:63-11:1. As a result, “the light transmission is invisible to the human eye.”

Ex-1006, 11:1-2. In effect, a POSITA would have understood that the infrared ink taught by Yuen increases the ratio of transmitted infrared light intensity to transmitted visible light intensity, as claimed, because it permits infrared light to pass through but not light that is visible to the human eye, thus decreasing the denominator and increasing the ratio. In practical terms, this means that the device can more effectively utilize infrared light for various functions, such as sensing and communication, while minimizing interference from visible light. The enhanced transmission of infrared light relative to visible light improves the device’s performance by ensuring that the infrared signals are stronger and more distinguishable from any ambient visible light. Additionally, the selective transmission characteristics provided by the infrared ink or lens contribute to the device’s stealth and aesthetic appeal. The emitted and received light remains invisible to the human eye, making the device more user-friendly and less intrusive.

235. As I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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 flexible layer made up of a material similar to the clear substrate 80 and is utilized for its light blocking characteristics.”).

236. 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 is toleranced 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 carried 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.”).

B. Ground 2: Claim 12 is obvious over Yuen in view of Schröder.

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.

237. 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. Both are directed to wearable biometric sensing devices having similar structural components including, for example, inner and outer surfaces, a cavity, and an electronic component (such

as batteries and microprocessors) within the cavity. *See, e.g.*, Ex 1006, 12:50-52 (“The biometric monitoring device is adapted (for example, includes a size and shape) to be worn or carried on the body of a user (for example, arm wrist, leg and/or ankle.”), Fig. 7 (showing device having an inner surface, cavity, and electronic component within the cavity); Ex 1007, 9:54-10:9 (“[T]he finger-ring 2 as an external secure unit 2 can have integrated therein at least one biometric sensor. The biometric sensor is connected suitably to the chip module 10 or it can be arranged in the finger-ring 2 separately from the chip module 10 e.g., on a separate circuit foil. The biometric sensor can be integrated into the finger-ring 2 e.g., such that the biometric sensor captures e.g., at least a partial vein image in the finger while the finger-ring 2 is being pushed over a finger.”), Figs. 6-10 (showing finger-ring having an inner surface, cavity, and electronic component within the cavity).

238. Yuen teaches that its 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 (“The device may be built in such a way that the sensor package/portion of the biometric monitoring device is removable and can be worn in any number of ways including, but not limited to, those listed above.”). Schröder discloses that its biometric sensing device is “a

finger-ring,” which “is worn by a user e.g., permanently on the finger.” Ex-1007, 3:61-62, 2:60-64 (“finger-ring” “consists of at least two components, with an electronic component being inserted into at least one component”).

239. 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 and is a design choice form factor that could be preferred in by some consumers as it could be worn if the user already wears a watch. 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 that its device is an “earring” or “toe band,” which a POSITA would have understood are structurally equivalent and/or functionally similar or identical to a “finger ring.” All these form factors share the common feature of being wearable accessories that can house biometric sensors without significant alteration to the user’s routine. Therefore, a POSITA would have recognized the feasibility and advantages of adapting Yuen’s device to a finger-ring structure. A ring structure is a widely recognized and common design element that offers several advantages for wearable devices. By encircling a part of the body, a ring design ensures a secure and stable fit, facilitating consistent and reliable contact

between the device and the body part. Ex-1006, 24:35-40 (“The device may be built in such a way that the sensor package/portion of the biometric monitoring device is removable and can be worn in any number of ways including, but not limited to, those listed above.”). 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 (“The finger-ring 2 as an external secure unit 2 is advantageously so configured that it cannot be taken away or employed without authorization or get lost, since it is worn as a ring on the finger.”). Thus, design incentives, consumer preferences, and market opportunities would have motivated a POSITA to apply the teachings of Schröder to Yuen.

240. A POSITA would have also understood that implementing Yuen’s device with Schröder’s finger-ring structure would enable a tighter fit (and therefore closer, with better and increased pressured coupling between body tissue and device) than a device worn, for example, on the user’s wrist, which would reduce motion artifact, provide better shielding against stray 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.” Ex-1006, 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.”).

241. As I explained in the Technology Background Section (*see* Section V), 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 diagnosis, monitoring, 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[.]”).

242. 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.

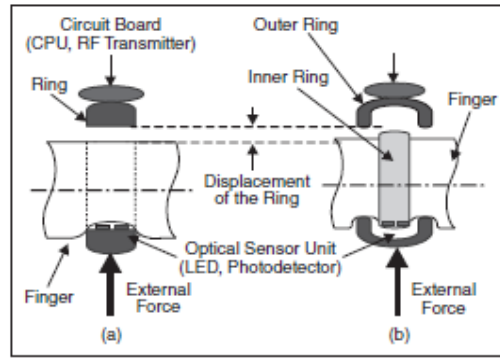


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force [31].

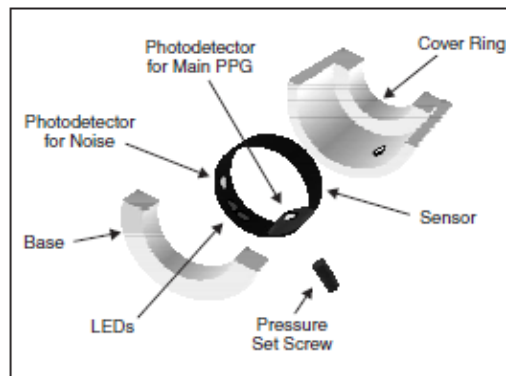


Fig. 15. The schematic of the Prototype C ring sensor.

243. 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.”).

244. 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).

245. Asada and his group also built and field-tested a transmittal PPG [photoplethysmograph] 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.”).

246. 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.”).

247. 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).

248. 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 wireless, wearable 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. Ex-1006, 24:35-40 (“The device may be built in such a way that the sensor

package/portion of the biometric monitoring device is removable and can be worn in any number of ways including, but not limited to, those listed above.”). 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. Dependent Claim 12: The wearable electronic device according to claim 1, wherein the body part comprises a ring configured to be worn on a finger.

249. Yuen in view of Schröder (“Yuen-Schröder”) teaches Claim 12.

250. Yuen teaches that its biometric monitoring device is secured to “an appendage of the user.” Ex-1006, 2:7-17. Specifically, Yuen teaches that the device can be worn on the user’s body, for example, on the user’s “arm, wrist, leg and/or ankle.” Ex-1006, 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 (“The device may be built in such a way that the sensor package/portion of the biometric monitoring device is removable and can be worn in any number of ways including, but not limited to, those listed above.”). While Yuen does not explicitly state that its device can be worn as a “finger ring,” a POSITA would have found it obvious that Yuen’s device could be worn in such a manner because an “earring” or “toe band” are structurally

equivalent and/or identical to a “finger ring” and would be worn and would function in a similar manner. All these form factors share the common feature of being wearable accessories that can house biometric sensors without significant alteration to the user’s routine. Therefore, a POSITA would have recognized the feasibility and advantages of adapting Yuen’s device to a finger-ring structure. A ring structure is a widely recognized and common design element that offers several advantages for wearable devices (e.g. secure and stable fit, consistent skin contact, comfort and wearability, discrete and aesthetic appeal, enhanced user compliance, etc.). By encircling a part of the body, a ring design ensures a secure and stable fit, facilitating consistent and reliable contact between the device and the body part. Ex-1006, 24:35-40 (“The device may be built in such a way that the sensor package/portion of the biometric monitoring device is removable and can be worn in any number of ways including, but not limited to, those listed above.”).

251. 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 of nutrients, oxygen, and waste products with tissues at these peripheral sites.

252. This limitation is also disclosed by Schröder. Schröder discloses a finger-ring device that utilizes biometric sensing to authenticate a user's identity for security purposes. Schröder discloses that its biometric sensing device is "a finger-ring," which "is worn by a user e.g., permanently on the finger." Ex-1007, 3:61-62.

253. As I explained in the Technology Background Section (*see* Section V), 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[.]”).

254. 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.

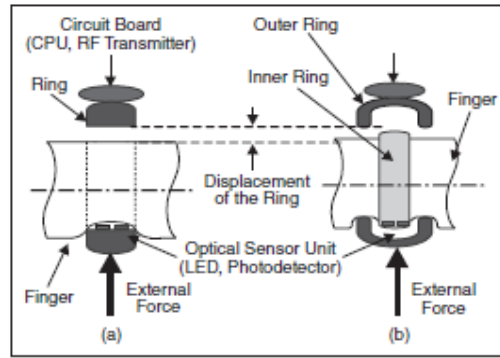


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force [31].

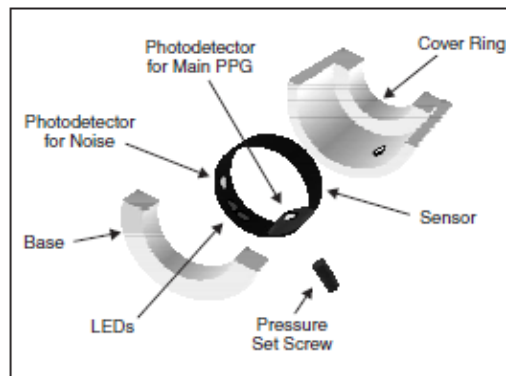


Fig. 15. The schematic of the Prototype C ring sensor.

255. 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.”).

256. 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).

257. Asada and his group also built and field-tested a transmittal PPG [photoplethysmograph] 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.”).

258. 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.”).

259. 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).

260. 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 for the same reasons discussed in Section VIII.B.1.

C. Ground 3: Claims 1-5, 7-9, and 12 are obvious over Schröder.

1. Independent Claim 1

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

261. Schröder teaches the preamble, to the extent it is limiting.⁶

⁶ As noted above, I understand that the Court in the *Circular* litigation found that the preamble of Claim 1 of the ’833 Patent is limiting. See Ex-1021, 2.

262. As shown below in Figure 1, Schröder teaches an electronic device, i.e., finger-ring 2, which can function as an “external secure unit” and communicate with a smartphone. Ex-1007, 3:57-59.

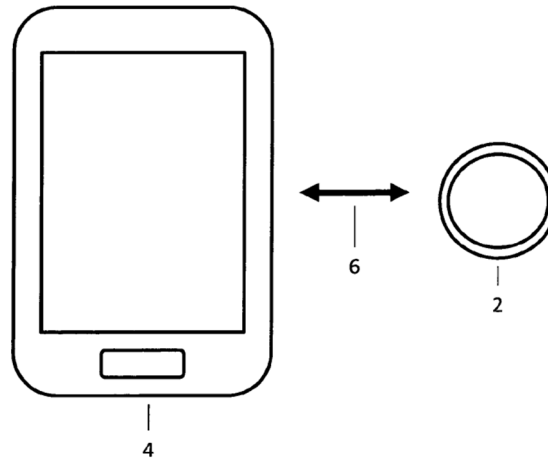


Fig. 1

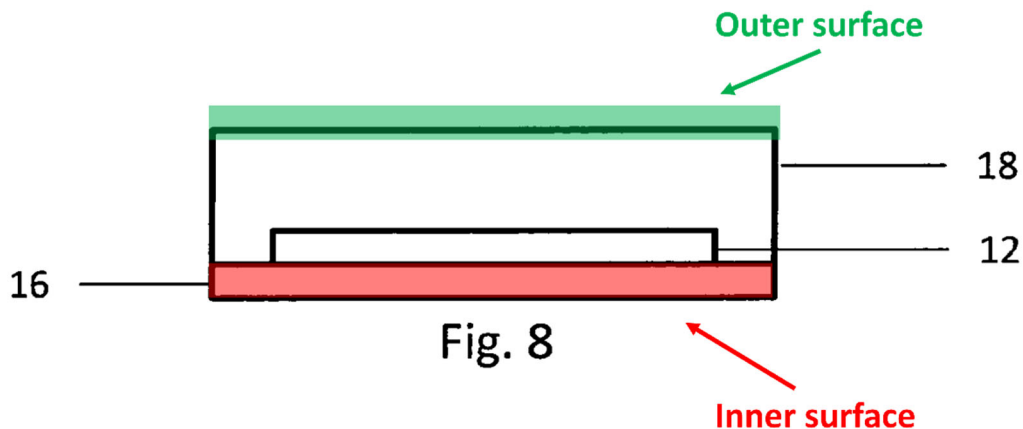
263. Schröder further teaches that the device is wearable: “[t]he finger-ring 2 is worn by a user, e.g., permanently on the finger.” *Id.*, 3:61-63.

b. Element 1[a]: a body part made of a non-ceramic material,

264. Schröder teaches Element 1[a].

265. As shown in Figure 8 below, Schröder teaches a finger-ring made of two concentric shells 16 and 18. Ex-1007, 12:50-52, Fig. 8. A POSITA would have understood that “body part” refers to a/the mechanical structure that encapsulates the optical and electronic components within its substructures, including walls and cavities. This structure is engineered to not only house but also mechanically constrain and stabilize the optical elements. Such design ensures that light paths are

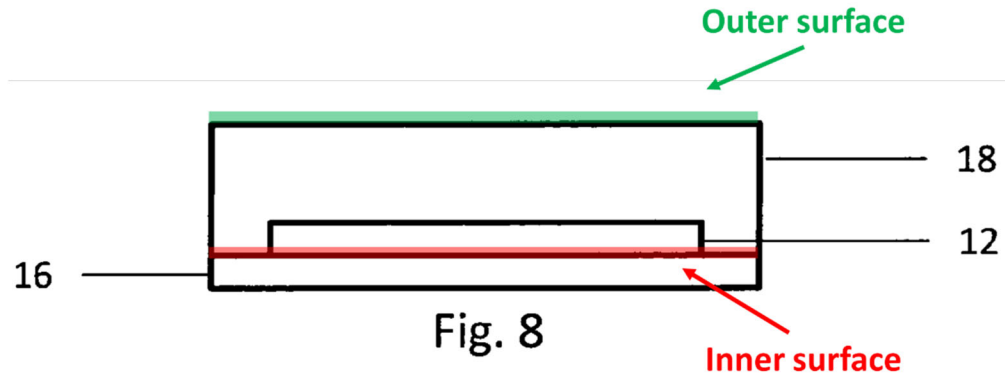
precisely directed from emitters, through the body tissue, and either through or back to the detectors. This structural body housing of components and pathways is critical for the device's functionality and efficiency. Under the plain and ordinary meaning of “body part,” a POSITA would have understood that Schröder teaches a “body part” in two ways. First, a POSITA would have understood Schröder’s entire finger-ring to be a “body part.” This interpretation arises from understanding that the finger-ring serves as a cohesive unit housing and integrating various components necessary for its operation. As shown in Figure 8, Schröder’s two-component ring has an outer surface (part of component 18, shown in green below) and an inner surface (component 16, shown in red below). Ex-1007, Fig. 8.



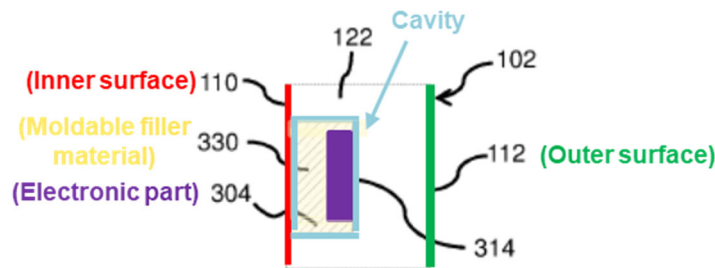
Schröder teaches that the entire finger-ring may be made of one material, as it teaches that the two ring components 16, 18 “can be manufactured from like or different materials.” Ex-1007, 12:56-57. Schröder further teaches that “[a]n expedient material for the components 16, 18 is plastic or metal.” Ex-1007, 12:14-

15. Schröder thus satisfies the claim requirement that the body part be made “of a non-ceramic material.” *See, e.g.*, Ex-1001, 4:17-20 (“**[N]on-ceramic material, such as plastic, metal** (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

266. A POSITA would also have understood that each of Schröder’s two finger-ring components—or halves—which are concentric rings themselves, is also a “body part.” A POSITA would have also recognized that each of the two components of Schröder’s finger-ring, which are designed as concentric rings, qualifies independently as a “body part.” These two halves are not just structural entities but functional segments that together complete the finger-ring’s purpose. Each segment is capable of supporting and stabilizing certain elements within the ring, playing a crucial role in the overall function and stability of the device. This distinction highlights the modular nature of the design, where each concentric ring, while part of a larger whole, is designed as a discrete unit within the system. For example, component 18 is a body part that has its own outer surface and inner surface. Ex-1007, Fig. 8.



267. These two interpretations are consistent with how a POSITA would have understood Figure 4 of the '833 Patent, which depicts inner surface 110 (annotated in red) and outer surface 112 (annotated in green). Ex-1001, Fig. 4.

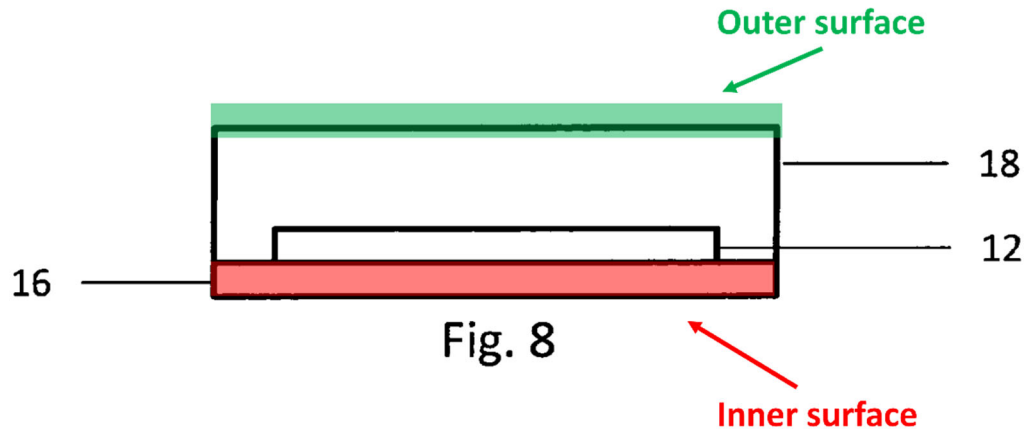


c. Element 1[b]: having an inner surface and an outer surface,

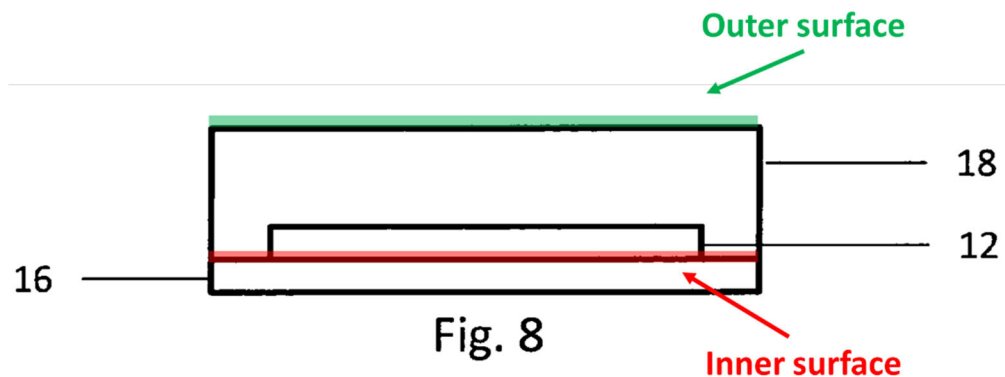
268. Schröder teaches Element 1[b].

269. Under a POSITA's first understanding described above, with the entire finger-ring being the claimed body part, Schröder's body part has an inner surface and an outer surface as depicted in Figure 8. Specifically, Schröder's finger-ring has two components—or halves—an outer surface (part of component 18, shown in

green below) and an inner surface (component 16, shown in red below). Ex-1007, Fig. 8.



270. Under the second interpretation of “body part” above, a POSITA would also have understood that each of Schröder’s two finger-ring components—or halves—have outer and inner surfaces. For example, component 18 has its own outer and inner surface. Ex-1007, Fig. 8; *see also* Ex-1001, Fig. 4 (depicting inner surface 110 (annotated in red) and outer surface 112 (annotated in green)).



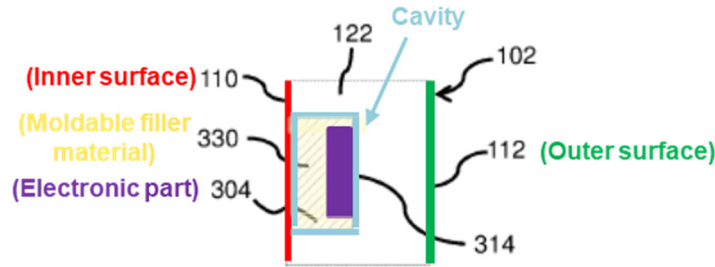
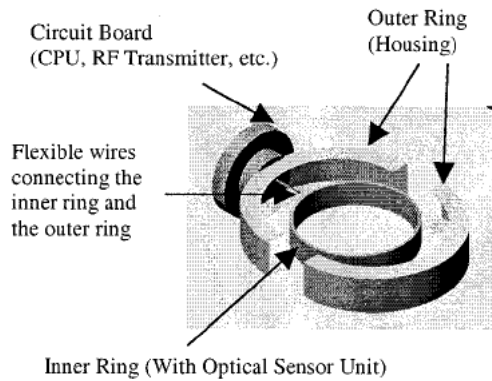
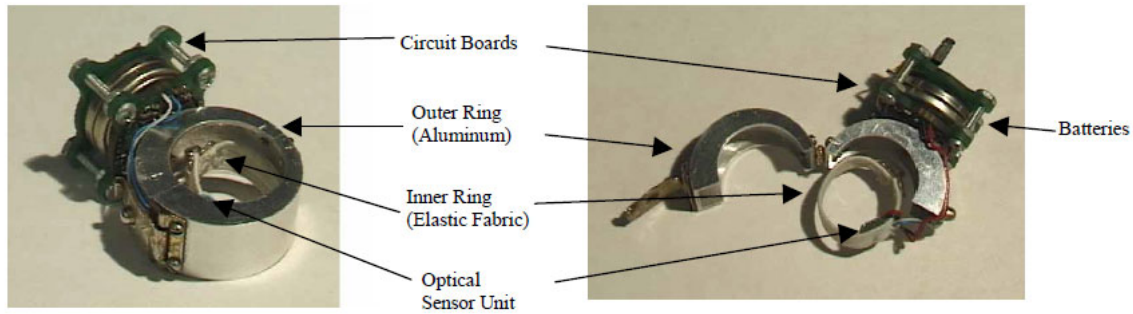


FIG. 4

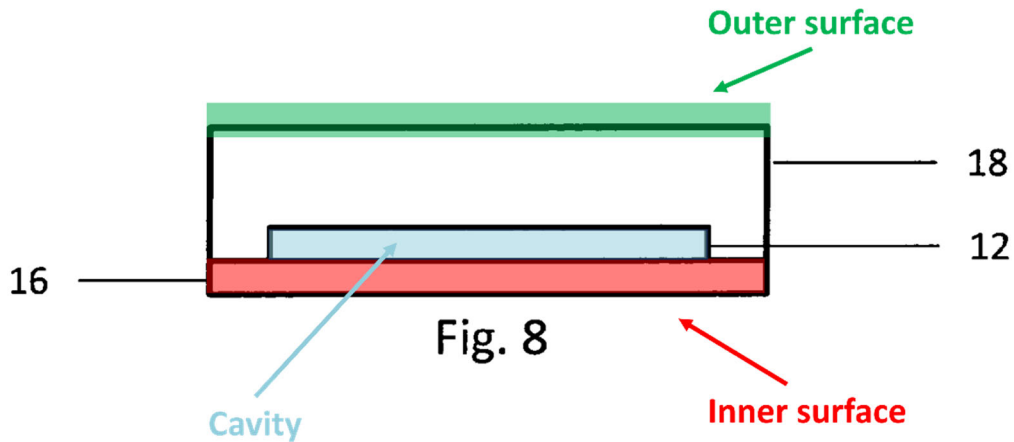
271. As I explained in the Technology Background Section (*see* Section V), finger-ring structures having inner and outer surfaces with electronics housed inside within a cavity were known. For example, Rhee's thesis and papers teach a finger-ring sensor having inner and outer surfaces. Specifically, 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).



d. Element 1[c]: wherein at least one cavity is formed on the inner surface of the body part,

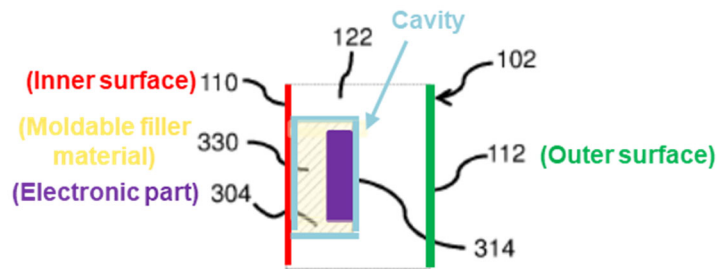
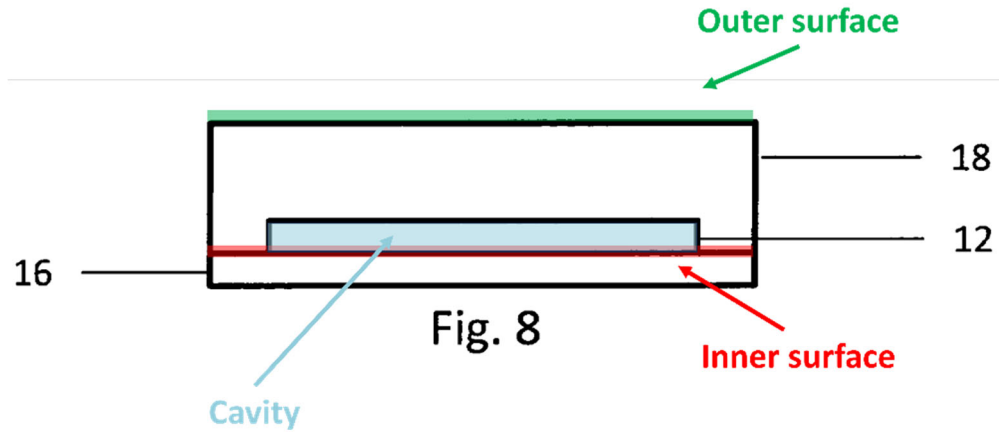
272. Schröder teaches Element 1[c].

273. Under a POSITA's first understanding described above, with the entire finger-ring being the claimed body part, Schröder teaches that a cavity (shown in blue in Figure 8 below) is formed on the inner surface, i.e., component 16 (annotated in red), of the body part. Ex-1007, Fig. 8.



274. A POSITA would have understood that the area annotated in blue is a cavity because Schröder refers to this area as a “recess of the finger-ring 2,” in which a chip module and/or an inlay can be inserted. Ex-1007, 8:58-59 (“The chip module 10 is inserted into a recess of the finger-ring 2.”), 12:10-12 (“The finger-ring 2 consists in principle of at least one component 16, 18 into which at least one inlay 12 is inserted, whereby one component can be a ring half 16, 18.”), 12:26-28 (“The inlay 12 is ... inserted into at least one recess provided therefor within at least one component [].”).

275. Schröder also teaches a cavity formed on the inner surface if the “body part” is one of the ring component shells such as component 18. For example, as shown in Figure 8 below, the cavity (blue) is formed on the inner surface of component 18 (red). Ex-1007, Fig. 8; *see also* Ex-1001, Fig. 4 (depicting inner surface 110 (red) and outer surface 112 (green)).



276. In a mechanical structure, a “cavity” refers to a hollow or enclosed space within the structure. This space can be intentionally created for various purposes, such as housing components, reducing weight, or facilitating certain mechanical functions like fluid flow or insulation. Cavities are critical in many engineering designs, influencing factors such as structural integrity, resonance characteristics, optical transmission paths, and thermal properties. The area annotated in blue in Figures 4 and 8 is a cavity formed on the inner surface of the device because it is a depression formed in the inner surface of the device and

because it is defined in part by the inner surface/wall of the device.

277. As I explained in the Technology Background Section (*see* Section V), by 2013, the formation of cavities, whether by single-structure formation or multi-structure assembly techniques, was known to be essential for integrating electronic components, optical components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This was known to be 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 were known to vary based on tooling sizes, costs, and complexities.

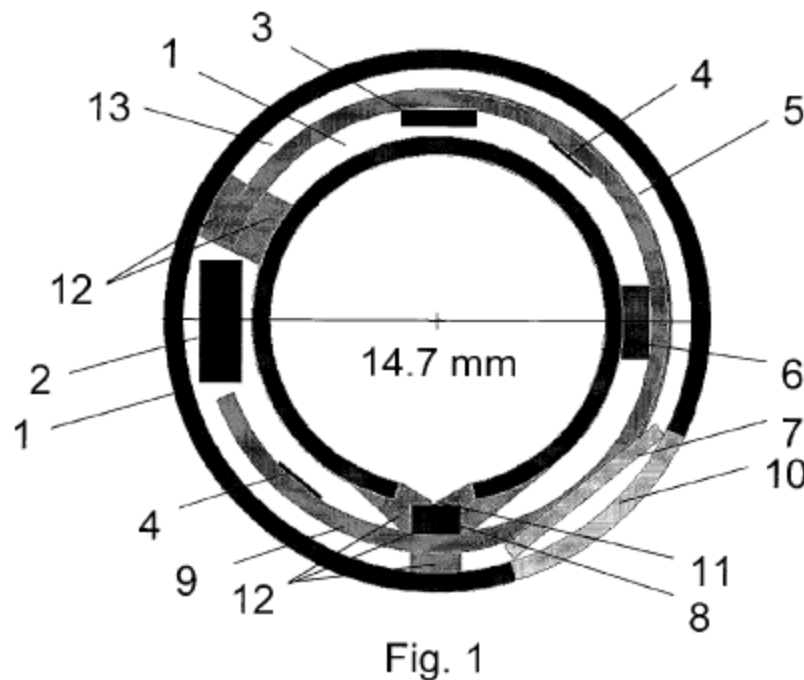
278. Most objects seen in everyday life are non-planar. Therefore, it is necessary that the electronic systems fit a convenient form factor of the shape into which it will be integrated.

279. 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 and were widely known as of 2013. 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 and

were known in 2013. 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 and were also known by 2013.

280. 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.



281. 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.

- e. **Element 1[d]: the at least one cavity extending from the inner surface of the body part towards the outer surface of the body part and having a depth arranged within the inner surface of the body part,**

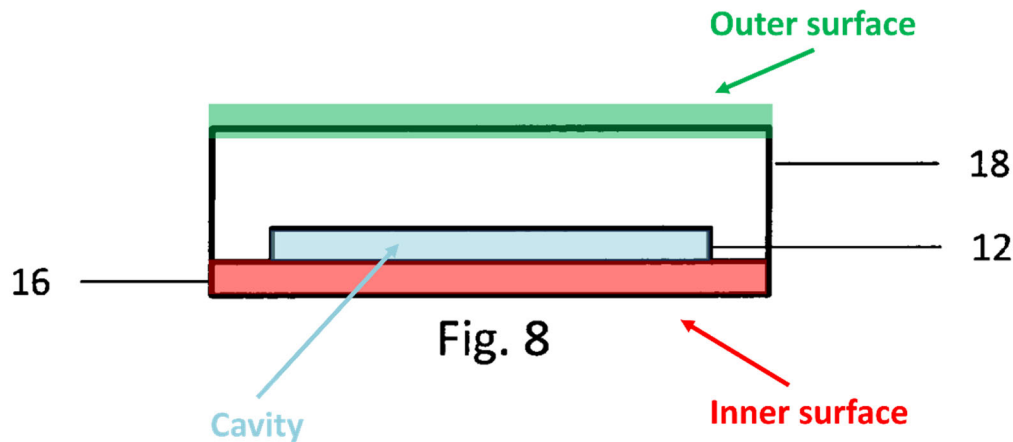
282. Schröder teaches Element 1[d].

283. Under a POSITA's first understanding described above, with the entire finger-ring being the claimed body part, Schröder teaches that the cavity (annotated in blue), which houses the chip module and/or inlay, extends from the inner surface (component 16, annotated in red) towards the outer surface (part of component 18, annotated in green) of the finger-ring, as shown in Figure 8 below. Ex-1007, Fig. 8.

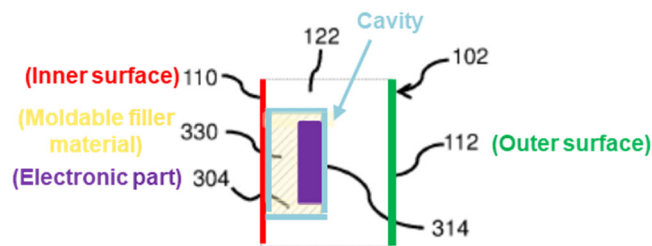
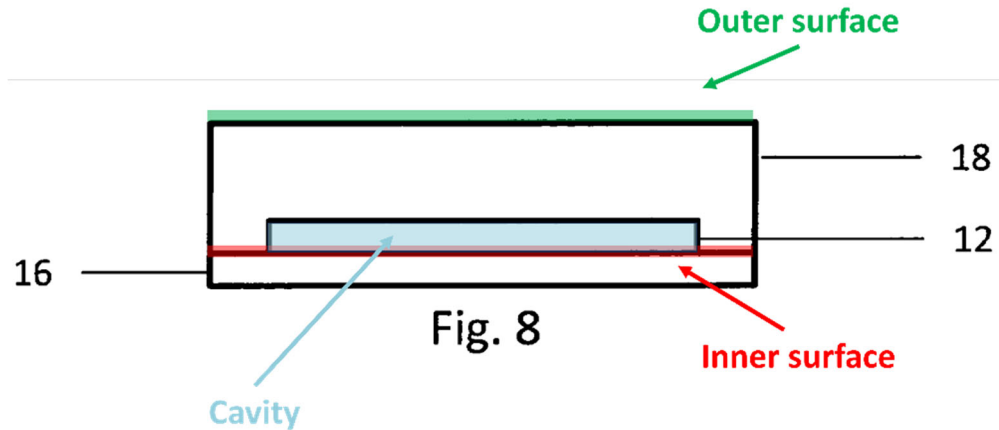
284. In a mechanical structure, a "cavity" refers to a hollow or enclosed space within the structure. This space is often intentionally designed for a variety of purposes, such as accommodating components, reducing overall weight, or enabling specific mechanical functions. Cavities are essential in numerous designs as they significantly impact a range of factors including structural integrity, accommodation of electronic assemblies, management of light and sound paths, and control of thermal properties. These considerations make cavities crucial for optimizing the performance and functionality of a system.

285. A POSITA would have understood that the cavity extending from the inner surface towards the outer surface of the body part has a depth arranged within the inner surface of the body part, as shown in the cross section in Figure 8. Ex-1007, 12:10-12, Fig. 8. A POSITA would have recognized that the cavity, which

extends from the inner surface toward the outer surface of the device, is designed with a boundary of the inner surface. The entirety of the cavity is enclosed within the surfaces of the device, meaning that the cavity does not breach the surfaces and remains completely contained within the interior limits set by the encompassing surfaces. This arrangement is crucial for maintaining the structural integrity of body while allowing for specific functionalities or component housing within the inner portions of the device.



286. Schröder also teaches that the cavity extends from the inner surface to the outer surface of the body part, if the “body part” is one of the ring component shells such as component 18. For example, as shown in the cross section in Figure 8 below, the cavity (annotated in blue) on the inner surface of component 18 extends to the outer surface of the body part. Ex-1007, Fig. 8; *see also* Ex-1001, Fig. 4 (depicting inner surface 110 (annotated in red) and outer surface 112 (annotated in green)).



A POSITA would have understood that the cavity extending from the Inner surface towards the outer surface of component 18 has a depth arranged within the inner surface of component 18, as shown in the cross section in Figure 8. Ex-1007, 12:10-12, Fig. 8. Moreover, the cavity is designed to include electronic components, which are 3-dimensional objects that themselves have a certain length, width, and depth. *See, e.g.*, Ex-1007, 13:27-35 (“Advantageously, a depression is manufactured in the carrier foil ... before the chip module 10, the antenna coil 8 and optional further electronic devices are inserted into the depression. The depression has the purpose that the devices to be inserted into the depression should not protrude beyond the

carrier foil if possible, so that an even surface is present on the carrier foil to facilitate a later processing of the carrier foil with inserted devices.”). Since the cavity must be large enough to house physical electronic components that have a certain depth, the cavity must also have a corresponding greater depth (i.e., the vertical thickness of the cavity (annotated in blue) in Figure 8).

287. As I explained in the Technology Background Section (*see* Section V), by 2013, the formation of cavities, whether by single-structure formation or multi-structure assembly techniques, was known to be essential for integrating electronic components, optical components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This was known to be 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 were known to vary based on tooling sizes, costs, and complexities.

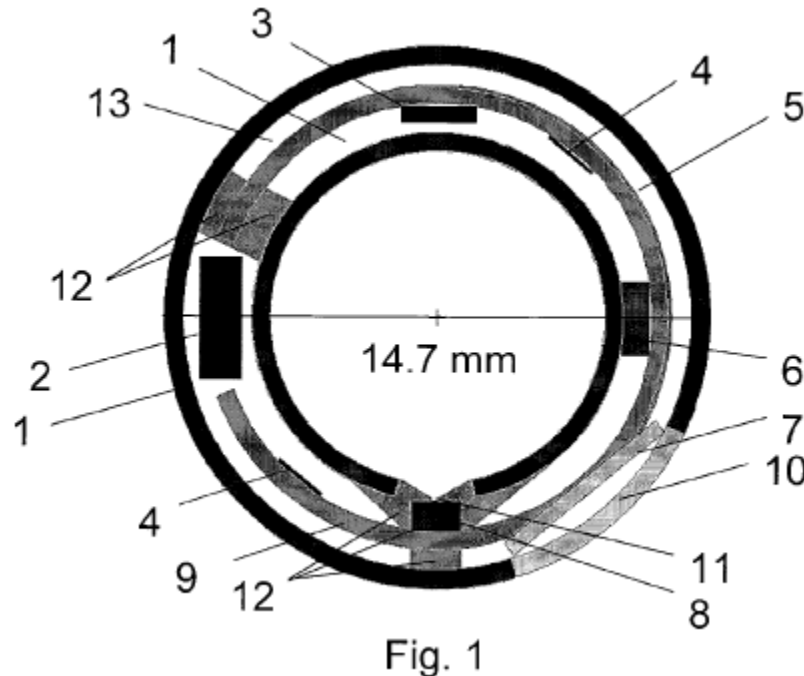
288. Most objects seen in everyday life are non-planar. Therefore, it is necessary that the electronic systems fit a convenient form factor of the shape into which it will be integrated.

289. 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 and were widely known as of 2013. 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 and were known in 2013. 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 and were also known by 2013.

290. 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.



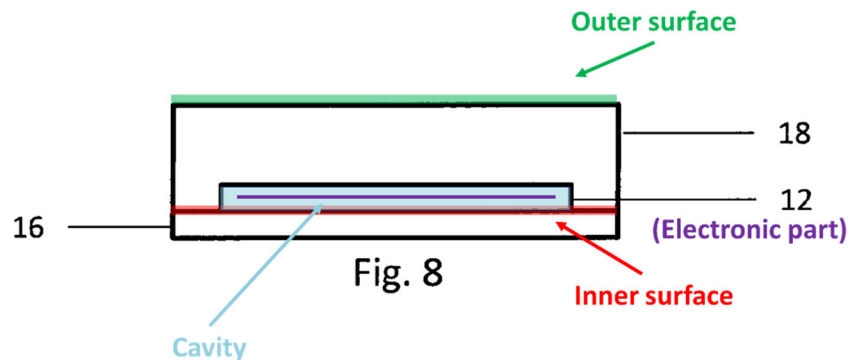
291. Similarly, U.S. Patent No. 6,201,698 to Hunter teaches that “the side walls and the web together create a cavity [] to house the electronic circuit.” Ex-

1060, 2:56-57.

f. Element 1[e]: an electronic part arranged in said at least one cavity,

292. Schröder teaches Element 1[e].

293. Schröder's finger-ring includes a "recess" (annotated in blue below) "within at least one component" such as component 18 where an inlay 12 (annotated in purple) is inserted. Ex-1007, 12:10-12, 12:26-32, Fig. 8. Schröder teaches that at least an antenna coil 8 and at least one chip module are arranged on inlay 12, which is preferably made of "a [] flexible carrier material." Ex-1007, 12:26-32. Schröder thus teaches an electronic part arranged within the cavity.



294. As I explained in the Technology Background Section (*see* Section V), by 2013, the formation of cavities, whether by single-structure formation or multi-structure assembly techniques, was known to be essential for integrating electronic components, optical components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This was known to be 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 were known to vary based on tooling sizes, costs, and complexities.

295. 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.

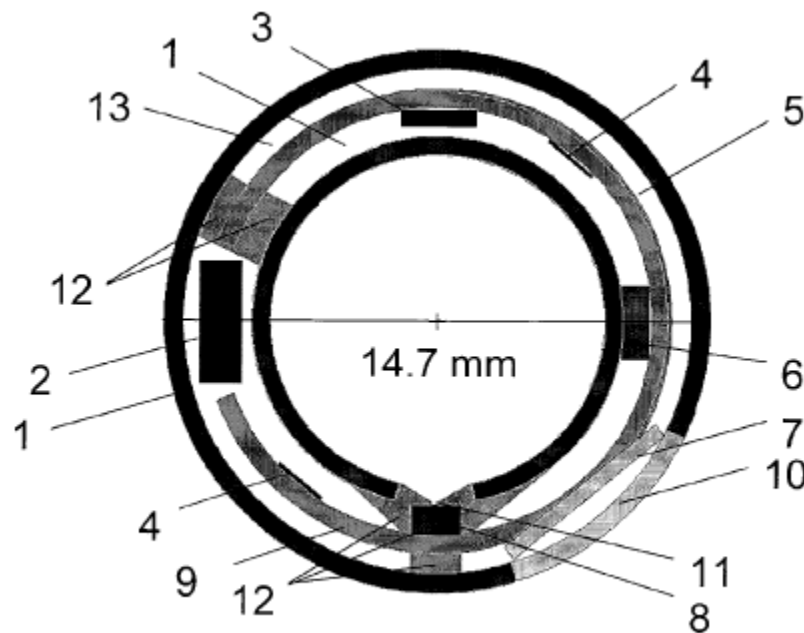
296. Creating a mechanical part from raw material involves bulk material removal, forming cavities or holes, and finishing to meet specifications. Techniques like milling, drilling, and EDM are commonly used and were widely known as of 2013. For difficult-to-machine materials, processes such as electro-discharge machining, laser beam machining, electron beam machining, shaped tube electrochemical machining, and electrochemical spark machining are employed and were known in 2013. 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 and were also known by 2013.

297. 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 was common as of 2013.

298. 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).

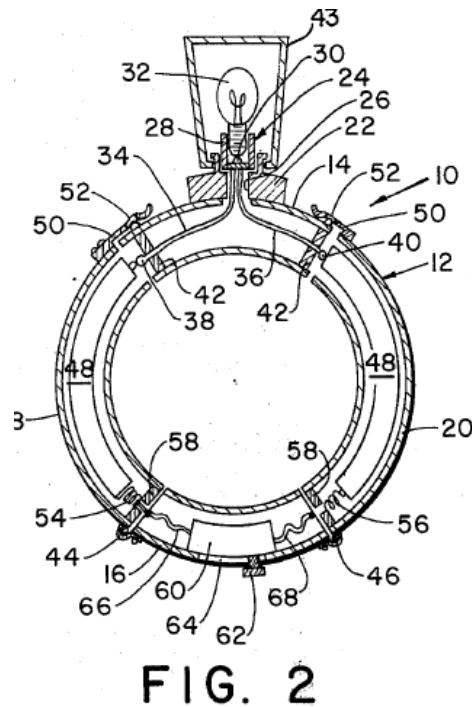
299. Further, by 2013 it was well understood that in order to house electronic components within wearable devices, there must be an internal space like a cavity within the mechanical, or structural, elements. From a manufacturing and assembly perspective, a cavity can either be premade, with electronic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



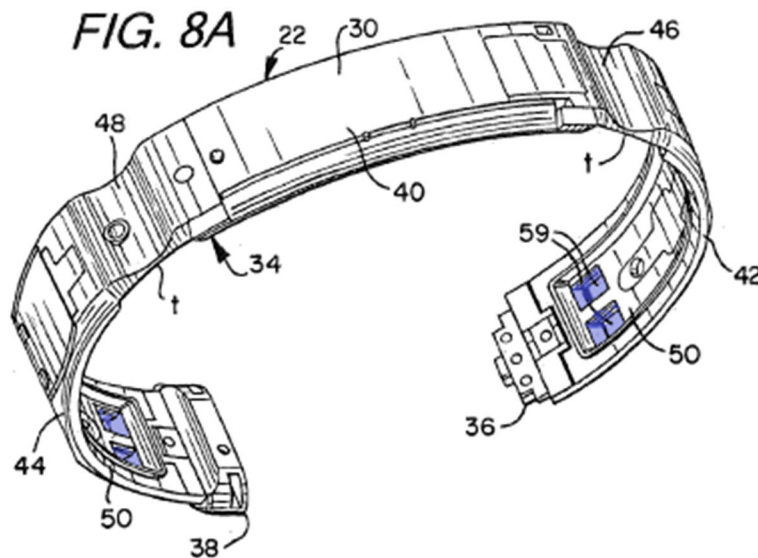
300. Similarly, U.S. Patent No. 6,201,698 to Hunter teaches that “the side walls and the web together create a cavity [] to house the electronic circuit.” Ex-1060, 2:56-57.

301. 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.



302. Moreover, U.S. Patent Publication No. 20140244009 to Mestas teaches an electronic wearable device that has “compartments” for its electronic components. Mestas’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.



303. Encapsulating electronics within a cavity of a structural element, for example, injection molding or potting, was well known by 2013. *See, e.g.*, Ex-1055, Ex-1056, Ex-1057, Ex-1058, and Ex-1059.

304. 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 patent 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).

g. Element 1[f]: which electronic part has a thickness that is less than the depth of the at least one cavity, and

305. Schröder teaches Element 1[f].

306. Schröder teaches that chip module 10 and/or inlay 12 are inserted *into* or *within* the recess of finger-ring 2. Ex-1007, 8:58-59 (“The chip module 10 is inserted *into* a recess of the finger-ring 2.”), 12:10-12 (“The finger-ring 2 consists in principle of at least one component 16, 18 *into* which at least one inlay 12 is inserted, whereby one component can be a ring half 16, 18.”), 12:26-28 (“The inlay 12 is ... inserted *into* at least one recess provided therefor *within* at least one component [.]”). A POSITA would have understood that the electronic part, i.e., chip module 10 and/or inlay 12, has a thickness less than the depth of the cavity

because the electronic part is inserted into or within the cavity and therefore must fit within the depth of the cavity. This design consideration is critical as it prevents the electronic components from protruding beyond the cavity, thus maintaining the intended structural and functional integrity of the device. This arrangement facilitates integration of the electronic components, while safeguarding its compact and contained design.

307. As I explained in the Technology Background Section (*see* Section V), by 2013, 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 patent 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).

308. Encapsulating electronics within a cavity of a structural element, for example, injection molding or potting, was well known by 2013. *See, e.g.*, Ex-1055, Ex-1056, Ex-1057, Ex-1058, and Ex-1059.

h. Element 1[g]: a coating made of a moldable filler material on the inner surface of the body part, covering the electronic part and the at least one cavity.

309. Schröder teaches Element 1[g].

310. The '833 Patent teaches that the moldable filler material “is filled in the cavity embedded with the electronic part” such that it “sealingly covers” the “electronic part and fills the remaining space of the cavity arranged on the inner surface of the molded body part.” Ex-1001, 5:46-54. The '833 Patent further teaches that the moldable filler material may comprise, for example, a low temperature moldable material such as a plastic or resin. *See, e.g.*, Ex-1001, 5:55-62.

311. As explained in the previous sections, Schröder’s electronic part is arranged in the cavity, which has a depth arranged within the inner surface of the body part. Schröder teaches that the electronic part and the cavity are covered by a coating made of a moldable material such as a low temperature moldable material (e.g., a plastic or resin). Ex-1007, 14:45-46 (“The material employed for this purpose is e.g., a plastic or a resin.”), 15:8-10 (“The finger-ring 2 consists for this purpose of at least two components. A first component consists of metal and a second component consists of plastic.”), 15:14-15 (“The second component consists e.g., of PET, PVC, carbon.”). Specifically, Schröder teaches that the finger-ring “can be manufactured by an injection-molding process.” Ex-1007, 14:35-37. Schröder explains the process as follows: the electronic part including, for example,

chip module 10 and antenna coil 8 “are arranged on a carrier foil”; “individual ring blanks” are “singled out of the carrier foil in different lengths ... to roll up the ring blanks in a ring shape”; and “a rolled or non-rolled ring blank” are “inserted into an injection mold to overmold the ring blank with a suitable injection-molding material,” such as a resin or plastic. Ex-1007, 14:38-46. The injection-molding process results in “a ring-shaped body in whose interior the chip module 10 and the antenna coil 8 and any further electronic devices are arranged.” Ex-1007, 14:46-49. Schröder additionally teaches that chip module 10 and antenna coil 8 may be “inserted into an injection mold in order to be overmolded.” Ex-1007, 14:50-53. This is consistent with the ’833 Patent’s teachings on a moldable filler material. Ex-1001, 5:46-62. A POSITA would have understood that Schröder’s molding material is a “moldable filler material” that fills in the cavity and encapsulates the electronic part within.

312. As I explained in the Technology Background Section (*see* Section V), using a moldable filler 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.

313. 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.

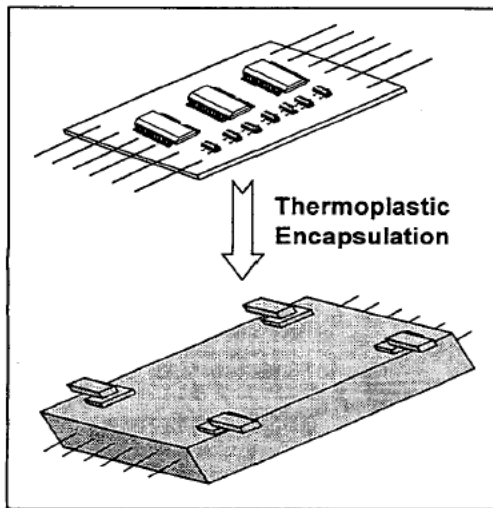


Figure 1. Illustration of the electronic overmoulding

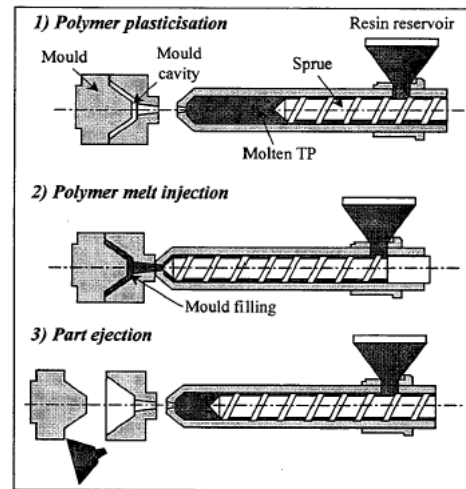


Figure 2. Schematic diagram of injection moulding

314. 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). 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 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.”).

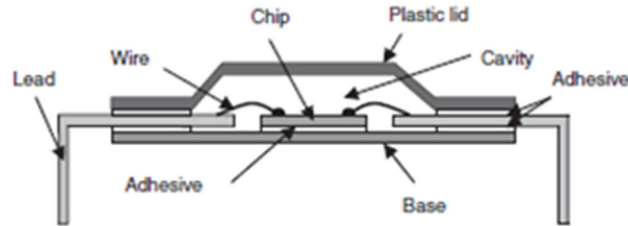


Figure 1.5 A pre-molded plastic package [9].

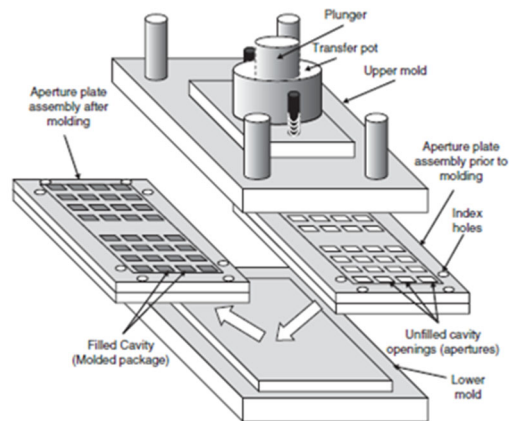


Figure 3.4 Aperture-plate (or cavity plate) molding setup [3].

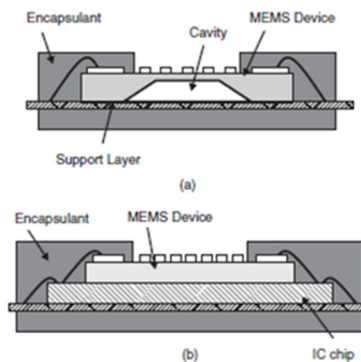


Figure 8.12 Plastic-encapsulated MEMS device package designs from Industrial Technology Research Institute: (a) MEMS device with a cavity; (b) 3D package with a MEMS device stacked on an IC chip [21].

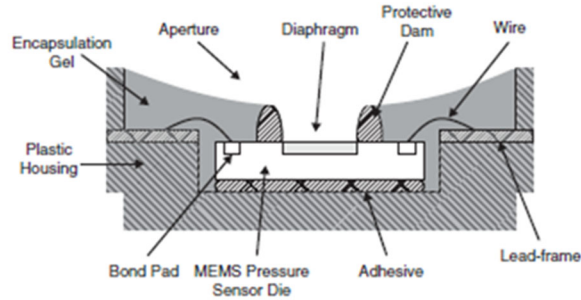


Figure 8.13 Plastic-encapsulated MEMS pressure sensor device from Motorola [22].

315. 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.”).

316. 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”).

317. As explained in Ground 1, Yuen uses a moldable filler material 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.

318. Yuen further emphasizes the importance of having a watertight seal of the device. See, e.g., *id.*, 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.

2. Dependent Claims 2-5, 7-9, and 12

a. Claim 2: The wearable electronic device according to claim 1, wherein the non-ceramic material is a titanium material.

319. Schröder teaches Claim 2.

320. Schröder teaches that at least one of the finger-ring components can be made of, for example, “silver, gold, *titanium*, steel.” Ex-1007, 15:9-11. Schröder also teaches that the finger-ring components 16 and 18 “can be manufactured from

like or different materials.” Ex-1007, 12:56-57. Titanium is a non-ceramic material. *See, e.g.*, Ex-1001, 4:17-20 (“***[N]on-ceramic material, such as plastic, metal*** (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

b. Claim 3: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable material.

321. Schröder teaches Claim 3.

322. Schröder teaches that “[a]n expedient material for the components 16, 18” of the finger-ring is metal or plastic. Ex-1007, 12:14-15. A metal material is a non-ceramic material. *See, e.g.*, Ex-1001, 4:17-20 (“***[N]on-ceramic material, such as plastic, metal*** (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

323. A POSITA would have understood that the metal materials taught by Schröder are machinable. As I explained in the Technology Background Section (*see* Section V), 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 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).

324. Moreover, a POSITA would have understood that using a machinable metal material in Schröder’s finger-ring such as a metal alloy would have been both obvious and preferable over other materials because a machinable metal material would have, for example, better corrosion or abrasion resistance, lower cost, higher strength, weight, rigidity, and desirable manufacturing workability. A POSITA would have considered metal among the material selection options for a design when evaluating design-choice trade-offs between select properties and in order to achieve desired product specification, manufacturability, and cost goals.

c. Claim 4: The wearable electronic device according to claim 1, wherein the non-ceramic material is a machinable titanium material.

325. Schröder teaches Claim 4.

326. Schröder teaches that at least one of the finger-ring components can be made of, for example, “silver, gold, *titanium*, steel.” Ex-1007, 15:9-11. Schröder also teaches that the finger-ring components 16 and 18 “can be manufactured from

like or different materials.” Ex-1007, 12:56-57.

327. A POSITA would have understood that titanium is a machinable material. As I explained in the Technology Background Section (*see* Section V), 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 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).

328. Moreover, a POSITA would have understood that using a machinable titanium material such as a titanium alloy in Schröder’s finger-ring would have been both obvious and preferable over other materials because a machinable titanium material would have, for example, better corrosion or abrasion resistance, higher strength (and strength to weight ratio), and better appearance. Moreover, a machinable titanium material is a non-ceramic material. *See, e.g.*, Ex-1001, 4:17-20

(“*[N]on-ceramic material, such as plastic, metal* (such as titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys), rubber or any combination thereof may be used for forming the molded body part.”).

- d. **Claim 5: The wearable device according to claim 1 wherein the non-ceramic material is a machinable metallic material comprising one or more of titanium, steel, platinum, gold, palladium, silver or bronze or a gold based alloys.**

329. Schröder teaches Claim 5.

330. Schröder teaches that at least one of the finger-ring components can be made of, for example, “*silver, gold, titanium, steel.*” Ex-1007, 15:9-11. Schröder also teaches that the finger-ring components 16 and 18 “can be manufactured from like or different materials.” Ex-1007, 12:56-57. Schröder further teaches that “[a]n expedient material for the components 16, 18 is plastic or metal.” Ex-1007, 12:14-15.

331. A POSITA would have understood that the metallic materials taught by Schröder are machinable. As I explained in the Technology Background Section (*see* Section V), 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 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).

332. A POSITA would have further understood that using a machinable metallic material in Schröder’s finger-ring such as a titanium or steel alloy would have been both obvious and preferable over other materials for the same reasons discussed in Sections VIII.C.2.b-VIII.C.2.c, namely, because a machinable metallic material would have, for example, better corrosion resistance, lower cost, higher strength, and better workability. A POSITA would have considered metal among the material selection options for a design when evaluating design-choice trade-offs between select properties and in order to achieve desired product specification, manufacturability, and cost goals.

- e. **Claim 8: The wearable electronic device according to claim 1, wherein the moldable filler material is selected from a group consisting of at least epoxy material, Polyethylene, Polyurethane, low temperature moldable material, Loctite M-31CL, alpha-epoxy, 1,2-epoxy, EpoxAcast® 650, Bisphenol S epoxy resin, Novolac epoxy resin, Aliphatic epoxy resin and Glycidylamine epoxy resin.**

333. Schröder teaches Claim 8.

334. Schröder teaches that the moldable filler material covering the electronic part and the cavity consists of at least Polyethylene or low temperature moldable material. Specifically, Schröder teaches that the material used for the injection molding process described in Section VIII.C.1.h, can be “*plastic* or a *resin*.” Ex-1007, 14:45-46. Schröder further teaches that the second component of the ring, which houses the electronic part, can be plastic, PET, or PVC. Ex-1007, 15:8-10, 15:14-15. Schröder additionally teaches that chip module 10 and antenna coil 8 (i.e., the electronic part in the cavity) may be “inserted into an injection mold in order to be overmolded.” Ex-1007, 14:50-53. Plastics, or synthetic resins, are broadly categorized into two types: thermosetting resins and thermoplastic resins. Polyvinyl chloride (PVC) belongs to the category of thermoplastic resins, which also includes polyethylene terephthalate (PET), polystyrene (PS), and polypropylene (PP). These thermoplastics are characterized by their ability to soften upon heating, allowing them to be reshaped and molded. A POSITA would have understood that PET and PVC are resins, which are curable, moldable, or workable at low temperatures such that they are “low temperature moldable material[s].”

335. As I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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 flexible layer made up of a material similar to the clear substrate 80 and is utilized for its light blocking characteristics.”).

336. 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 is toleranced 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 carried 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.”).

337. Thus, Schröder teaches Claim 8.

f. Claim 9: The wearable electronic device according to claim 1, wherein the electronic part comprises one or more of a battery, an infrared transmitter, a microcontroller, a radio frequency transceiver, a temperature sensor and an infrared receiver.

338. Schröder teaches Claim 9.

339. Schröder’s electronic part may include a radio frequency transmitter.

Schröder teaches “an antenna coil 8 for a first frequency, e.g., for an NFC application, as well as a chip module 10 which optionally also has an antenna coil for a second frequency.” Ex-1007, 5:14-16. A POSITA would have recognized that the description provided by Schröder implies more than just a simple transmitter; it necessitates the presence of a radio frequency transceiver. A POSITA would have recognized that Schröder’s electronic part is designed not just to emit signals but also to receive them, supporting communication. A POSITA would have understood that these Schröder teachings correspond to and would require Schröder’s electronic part to include a radio frequency transceiver.

340. Schröder’s electronic part may include a microcontroller. Schröder teaches that its finger-ring may include “a plurality of processors.” Ex-1007, 2:53-56. Moreover, Schröder teaches that chip module 10 “has at least two physically mutually separate processors,” which a POSITA would have understood to teach a microcontroller. Ex-1007, 10:60-61.

341. Schröder’s electronic part may include a battery. Schröder teaches that its finger-ring “has an energy storage device, e.g., an accumulator or a battery,” which is “connected to the chip module 10 in order to supply the chip module 10 with energy outside an electromagnetic field of a reader.” Ex-1007, 11:46-50.

342. Schröder’s electronic part may also include an infrared transmitter and receiver. Schröder teaches that the energy storage device can “operate alternative

communication channels, such as wireless LAN, infrared, etc., which are likewise supported by the chip module 10.” Ex-1007, 11:55-58; *see also id.*, 6:42-48 (an infrared diode may be connected to chip module 10 via an electronic circuit, which switches the ring protocol from NFC to “an infrared transfer”), 10:1-2 (infrared diode and infrared sensor are arranged “opposite each other”).

343. As I explained in the Technology Background Section (*see* Section V), it was known by 2013 that 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).

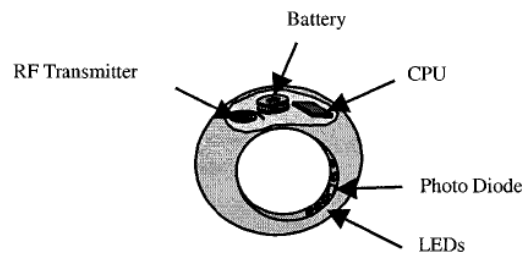


Fig. 1. Conceptual diagram of the ring sensor.

344. 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 module 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.”).

g. Claim 12: The wearable electronic device according to claim 1, wherein the body part comprises a ring configured to be worn on a finger.

345. Schröder teaches Claim 12.

346. 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; *see also id.*, 9:54-10:9 (the finger-ring has a biometric sensor that captures “at least a partial vein image in the finger while the finger-ring 2 is being pushed over a finger”).

347. As I explained in the Technology Background Section (*see* Section V), wearable electronic devices, including various design problems and proposed solutions for implementing such devices, were well-known to a POSITA by 2013. For example, it was known by 2013 that wearable photoplethysmographic biosensors could be used for the 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[.]”).

348. 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.

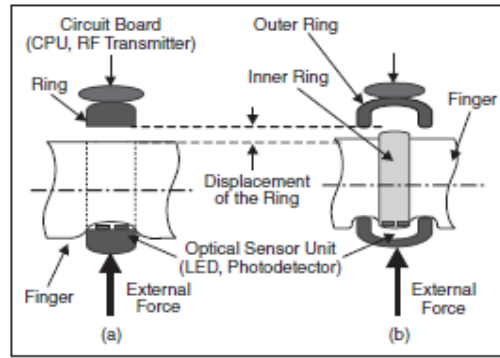


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force [31].

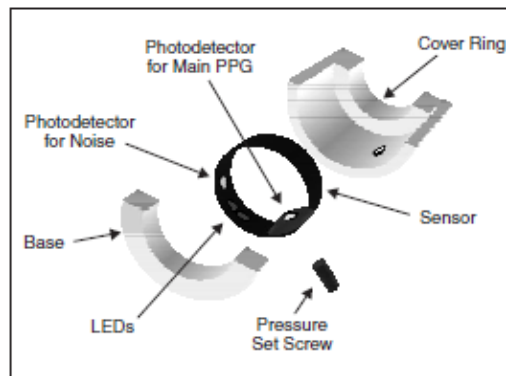


Fig. 15. The schematic of the Prototype C ring sensor.

349. 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.”).

350. 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).

351. Asada and his group also built and field-tested a transmittal PPG [photoplethysmograph] 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.”).

352. 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.”).

353. 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).

D. Ground 4: Claims 6-7 and 10-11 are obvious over Schröder in view of Yuen.

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

354. A POSITA would have been motivated to combine the teachings of Schröder and 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, inner and outer surfaces, a cavity, and an electronic component (such as batteries and microprocessors) within the cavity. *See, e.g.*, Ex 1007, 9:54-10:9

(“[T]he finger-ring 2 as an external secure unit 2 can have integrated therein at least one biometric sensor. The biometric sensor is connected suitably to the chip module 10 or it can be arranged in the finger-ring 2 separately from the chip module 10 e.g., on a separate circuit foil. The biometric sensor can be integrated into the finger-ring 2 e.g., such that the biometric sensor captures e.g., at least a partial vein image in the finger while the finger-ring 2 is being pushed over a finger.”), Figs. 6-10 (showing finger-ring having an inner surface, cavity, and electronic component within the cavity); Ex 1006, 12:50-52 (“The biometric monitoring device is adapted (for example, includes a size and shape) to be worn or carried on the body of a user (for example, arm wrist, leg and/or ankle.”), Fig. 7 (showing device having an inner surface, cavity, and electronic component within the cavity).

355. Schröder’s finger-ring includes a “recess” (i.e., cavity) within at least one of its components (16, 18) where an electronic part (e.g., chip module 10 and/or inlay 12) is inserted. Ex-1007, 12:10-12 (“The finger-ring 2 consists in principle of at least one component 16, 18 into which at least one inlay 12 is inserted, whereby one component can be a ring half 16, 18.”), 12:26-28 (“The inlay 12 is ... inserted into at least one recess provided therefor within at least one component [].”); 15:26-28 (“the carrier can also be connected firmly to the second component, e.g., by means of a glue”). 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; *see also id.*, 14:50-53 (“the chip module 10 and the antenna coil 8 are interconnected electroconductively without being arranged on a carrier foil, and subsequently inserted into an injection mold in order to be overmolded”). Yuen’s device also includes a cavity that houses an electronic part (e.g., optical sensors with LEDs and a photodetector) and explicitly teaches that the electronic part is “pressed or secured to the housing surface such that the optical components are flush to the housing surface.” Ex-1006, 12:42-45. Moreover, Yuen teaches an optical transparent layer that covers the electronic part and cavity of the device, which “may be formed through in-mold labeling or ‘IML.’” Ex-1006, 2:44-45. Yuen further teaches that “the circuitry related to emitting and receiving light may be disposed in the interior of the device housing and underneath a plastic or glass layer (for example, painted with infrared ink) or an infrared lens which permits infrared light to pass but not light in the human visual spectrum.” Ex-1006, 10:63-11:1. As a result, “the light transmission is invisible to the human eye.” Ex-1006, 11:1-2.

356. A POSITA would have been motivated to attach the electronic part in Schröder’s finger-ring at the bottom of the cavity, as Yuen explicitly teaches, because it would provide, for example, a higher mechanical rigidity reducing the likelihood for relative motion between the body part and electronic part, less variable sensor reading, reduction of noise at least because of decreased pathways for “stray” light, vibration tolerance, and damage protection for the device. Schröder teaches

that the biometric sensor should capture “at least a partial vein image in the finger while the finger-ring 2 is being pushed over a finger.” Ex-1007, 9:62-66. Yuen 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) because it “may increase the quality of the cardiac signal of interest.” Ex-1006, 13:54-62; *see also id.*, 14:25-32 (“Notably, the user 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, whilst the user is in motion.”). Additionally, it was known to a POSITA at the time of the invention that electronic devices including wearable electronic devices are vulnerable to shock, damage, and vibrations, for example, if they are dropped or hit against hard surfaces. Attaching the electronic part to the bottom of the cavity of the device would have been an obvious design choice to mitigate extreme vibrations and damage to the device.

357. A POSITA would have also been motivated to include an ink, as explicitly taught by Yuen, with Schröder’s moldable filler material because it would prevent stray light and focus the emission/receiving of sensing light to specific

regions on the sensors of the device (e.g., the infrared transmitter and infrared receiver regions), resulting in a more accurate reading from the sensors. A POSITA would have been motivated to include an ink with Schröder's moldable filler material that allows preferential transmission of infrared light such that the ink increases a value of transmitted infrared light intensity divided by transmitted visible light intensity, as taught by Yuen, for similar reasons; namely, because it would allow the sensors of the device to select which wavelengths to transmit/receive sensing light on and which wavelengths to filter out, thus enabling a higher quality reading from the sensors. For example, Yuen teaches that selectively transmitting "light having one or more specific or predetermined wavelengths with higher efficiency than others, thereby acting as a bandpass filter," may "improve the signal of a specific physiological data type." Ex-1006, 11:14-21. A POSITA would thus have understood that it would have been desirable for certain regions of Schröder's finger-ring surface to be opaque to certain sensing light wavelengths so that the sensors of the device know exactly what wavelengths are being transmitted and can then accurately calculate the desired properties that the sensors are trying to measure (e.g., oxygen blood flow, vein texture, etc.) from the wavelengths that are received while filtering out the undesirable wavelengths.

358. As I explained in the Technology Background Section (*see* Section V), 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).

359. 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).

360. 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).

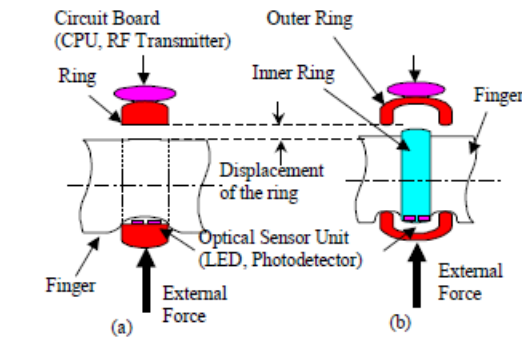


Figure 2 : Dislocation of ring sensors due to external load
(a) Traditional single body design under external force
(b) New isolating ring sensor under external force

361. 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).”).

362. Additionally, as I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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.”).

363. 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 is toleranced 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 carried 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.”).

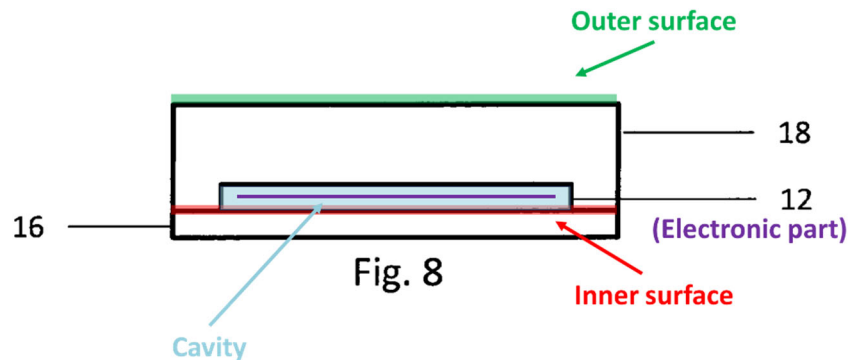
364. A POSITA would have had a reasonable expectation of success in combining Schröder and Yuen. Schröder and Yuen are analogous prior art as they both involve biometric sensing devices having similar structural components such as inner and outer surfaces and a cavity housing an electronic part. Moreover, a POSITA would have understood that the electronic components of Schröder and Yuen’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. Ex-1006, 24:35-40 (“The device may be built in such a way that the sensor package/portion of the biometric monitoring device is removable and can be worn in any number of ways including, but not limited to, those listed above.”). 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. Dependent Claims 6-7 and 10-11

- a. Claim 6: The wearable electronic device according to claim 1, wherein the electronic part is attached to the [at least one] cavity [at] a bottom of the [at least one] cavity.⁷**

365. Schröder in view of Yuen (“Schröder-Yuen”) teaches Claim 6.

366. As discussed in Ground 3 (Sections VIII.C.1.f-VIII.C.1.g), Schröder teaches that the electronic part (e.g., inlay 12 (annotated in purple)) is arranged in the cavity (annotated in blue). Ex-1007, 12:10-12, 12:26-32, Fig. 8.



367. Schröder teaches that “inlay 12 itself consists of a preferably flexible carrier material, e.g., PET, Kapton, etc.” Ex-1007, 12:28-29. Because inlay 12 consists of a flexible carrier material such as Kapton, which is the material of a

⁷ I understand from Counsel that in the *Circular* litigation, where Patent Owner asserted the ’833 Patent against an unrelated party, Patent Owner argued and the Court stated that Claim 6 is not indefinite and should read “the at least one cavity at a bottom of the at least one cavity.” See Ex-1021, 2. For purposes of this Petition only, I adopt the Court’s construction of Claim 6 from the *Circular litigation*, but by doing so, I do not intend to, and do not, waive any argument that Claim 6 is indefinite in any future district court litigation against PO.

flexible printed circuit board, a POSITA would have understood that inlay 12 would be attached to the bottom of the cavity to enable a higher mechanical rigidity reducing the likelihood for relative motion between the body part and electronic part, less variable sensor reading, reduction of noise at least because of decreased pathways for “stray” light, vibration tolerance, and damage protection for the device. Attaching inlay 12 to the bottom of the cavity would have been an obvious design choice to mitigate extreme vibrations and damage to the device.

368. To the extent that Schröder does not explicitly teach attaching the electronic part to the bottom of the cavity, this is taught by Yuen. As discussed above at Ground 1 (Section VIII.A.2.e), a POSITA would have understood that the bottom of the cavity is the end of the cavity that is away from the inner (skin-side) surface of the device. Figure 7C of the '833 Patent, depicted below, is consistent with this understanding, as it shows the electronic part 314 (annotated in purple) attached to the end of the cavity (annotated in blue) away from the inner (skin-side) surface 110 (red) of the device. Ex-1001, Fig. 7C.

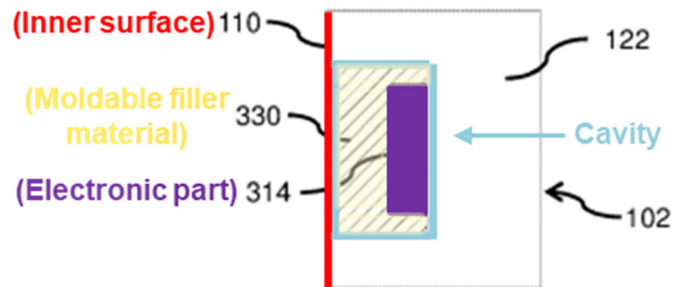
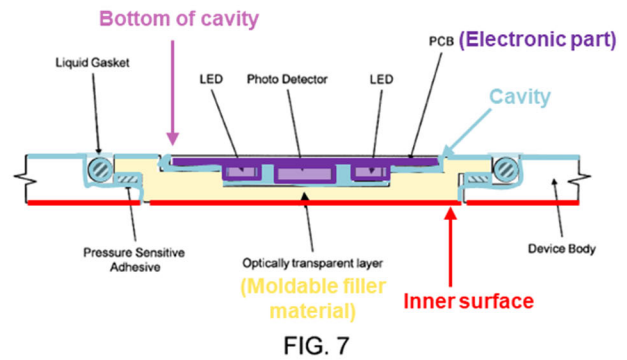
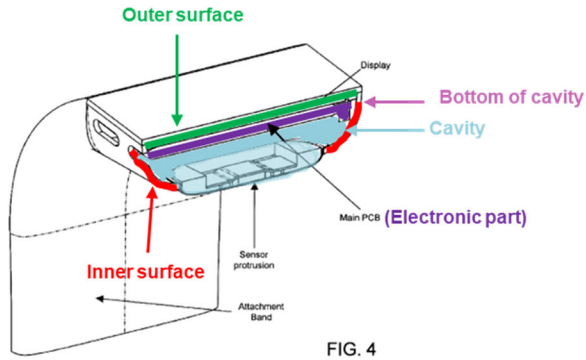


FIG. 7C

369. Yuen teaches that the electronic part (i.e., the main PCB and any LEDs and/or photodetectors positioned on it (Ex-1006, 2:38-39)) is attached to the bottom of the cavity, i.e., away from the inner (skin-side) surface of the biometric monitoring device. Yuen’s optical sensors including the LEDs and photodetector are positioned “on an interior or skin side of the biometric monitoring device (i.e., a side whereby the surface of the device contacts, touches and/or faces the skin of the user (hereinafter ‘skin side’).” Ex-1006, 9:57-61; see also *id.*, 12:55-61 (“In one embodiment, optical elements of the optical heart rate monitor are disposed or located on the interior or skin side of the biometric monitoring device, for example, facing the top of the wrist (i.e. the optical heart rate monitor is juxtaposed the wrist) when the device is wrist mounted.”). The LEDs/photodetector are further positioned “on a flexible or pliable substrate,” such as a flexible PCB, which allows the inner surface of the device to adapt to the shape of the user’s appendage (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 ("In one embodiment, the 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.")). Yuen teaches that "optical components of differing heights may be mounted to different 'fingers'" of the flexible PCB "and pressed or secured to the housing surface such that the optical components are flush to the housing surface." Ex-1006, 12:42-45.

370. A POSITA would have understood, as depicted in Yuen's Figures 4 and 7, that the electronic part (annotated in purple) is attached to the cavity (annotated in blue) at the bottom of the cavity, i.e., away from the inner surface. Ex-1006, Figs. 4 (depicting a cross-sectional "through the electronics package" (PCB)), 7 (depicting a cross-sectional view of the PPG sensor with the LEDs and photodetector positioned on the PCB). For example, Figure 4 shows that the main PCB is located and attached to the base (bottom) portion of the cavity (blue). Figure 7 shows that the main PCB (including the LEDs and photodetector positioned on it) are located and attached to the base (bottom) portion of the cavity (blue).



371. A POSITA would have understood that it would have been beneficial to have the electronic part attached to the bottom of the cavity for a number of reasons including because it would provide a higher mechanical rigidity reducing the likelihood for relative motion between the body part and electronic part, less variable sensor reading, reduction of noise at least because of decreased pathways for “stray” light, vibration tolerance, and damage protection for the device. Electronic devices including wearable electronic devices are vulnerable to shock, damage, and vibrations, for example, if they are dropped or hit against hard surfaces. Attaching the electronic part to the bottom of the cavity of the device would have been an obvious design choice to mitigate extreme vibrations and damage to the device, and to simplify, reduce variation, improve quality, reduce time of overall manufacturing assembly.

372. As I explained in the Technology Background Section (*see* Section V), 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

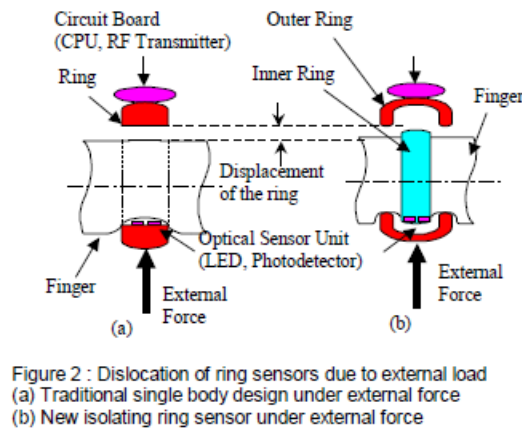
example, the Konig reference teaches that, in transmission pulse oximetry “[t]he optical elements are located on the opposite sides of a body part” and “[t]he sensors are applied mainly to the fingers and toes.” Ex-1027, 405 (Konig).

373. 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).

374. 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).



375. 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).”).

376. A POSITA would have been motivated to combine the teachings of Schröder and Yuen and would have had a reasonable expectation of success in doing so for the same reasons discussed in Section VIII.D.1.

b. Claim 7: The wearable electronic device according to claim 6, comprising one or more of a sticker, a tape or glue that attaches the electronic part to the at least one cavity at a bottom of the at least one cavity.

377. Schröder-Yuen teaches Claim 7. As discussed in the previous section, the Schröder-Yuen combination teaches that the electronic part is attached to the cavity at the bottom of the cavity.

378. Schröder teaches that a glue is used to attach Schröder’s electronic components, such as the chip module or the carrier foil, to the bottom of the cavity. Specifically, Schröder teaches that chip module 10 may be permanently connected “to the contacts of the inlay 12, e.g., by soldering, crimping, gluing, etc.” Ex-1007, 9:13-15; *see also id.*, 15:15-18 (“[t]he second component has arranged therein the chip module 10 and the antenna coil 8 and possibly at least one further electronic device, e.g., a display”), 15:26-28 (“the carrier can also be connected firmly to the second component, e.g., by means of a glue”).

- c. **Claim 10: The wearable electronic device according to claim 9, wherein the moldable filler material comprises an ink and is configured to cover at least an area other than the infrared transmitter and the infrared receiver within the at least one cavity.**

379. Schröder-Yuen teaches Claim 10.

380. Schröder teaches that its finger-ring incorporates “security elements ... into the surface,” including, for example, “fluorescent or phosphorescent inks, optically variable inks, color gradations, e.g., gradients, iridescent print, intaglio print,” or “transparent regions.” Ex-1007, 9:28-34. A POSITA would have found it obvious to also incorporate an ink into Schröder’s moldable filler material in order to achieve particular optical transmission, reflection, or absorption properties.

381. This limitation is also taught by Yuen for the reasons discussed in Ground 1 (Section VIII.A.2.i). Yuen teaches that the moldable filler material comprises an ink and covers an area between the optical components and the inner (skin-side) surface of the cavity. Specifically, as depicted in Figure 7, Yuen teaches an optical transparent layer (annotated in yellow), which “may be formed through in-mold labeling or ‘IML.’” Ex-1006, 2:44-45, Fig. 7. Yuen teaches that the biometric monitoring device may include a material placed on the inner (skin-side) surface that “includes high reflectivity characteristic—for example, polished stainless steel, *reflective paint*, and polished plastic,” which allows light to be scattered and/or reflected “off the skin side of the device ... back into the skin.” Ex-

1006, 15:15-21. Yuen teaches that this material improves SNR by effectively increasing “the input light signal” as compared to a non-reflective device surface. Ex-1006, 15:21-23. Yuen further teaches that “the circuitry related to emitting and receiving light may be *disposed in the interior of the device housing* and underneath a plastic or glass layer (for example, *painted with infrared ink*) or an infrared lens which permits infrared light to pass but not light in the human visual spectrum.” Ex-1006, 10:63-11:1.

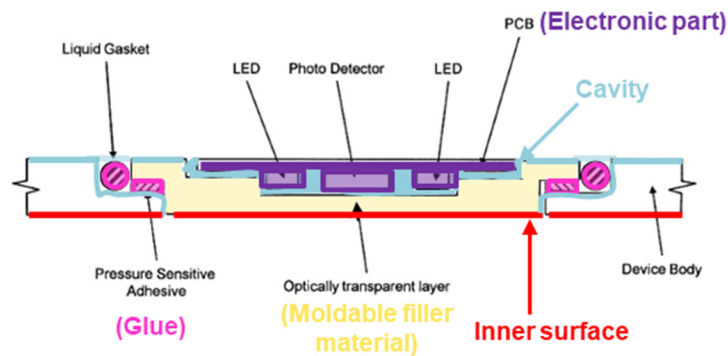


FIG. 7

382. A POSITA would have understood that the infrared ink taught by Yuen would be applied to the optically transparent layer (annotated in yellow) within the cavity (annotated in blue), as depicted in Figure 7, where it is shown to cover at least an area other than that corresponding to the LEDs and the photodetector in order to obtain beneficial optical properties relating to blocking or some wavelength and transmission of some wavelengths.

383. As I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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 flexible layer made up of a material similar to the clear substrate 80 and is utilized for its light blocking characteristics.”).

384. 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 is toleranced 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 carried 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.”).

385. A POSITA would have been motivated to combine the teachings of Schröder and Yuen and would have had a reasonable expectation of success in doing so for the same reasons discussed in Section VIII.D.1.

- d. **Claim 11: The wearable electronic device according to claim 1, wherein the moldable filler material comprises an ink that increases a value of transmitted infrared light intensity divided by transmitted visible light intensity.**

386. Schröder-Yuen teaches Claim 11.

387. Schröder teaches that its finger-ring incorporates “security elements ... into the surface,” including, for example, “fluorescent or phosphorescent inks, optically variable inks, color gradations, e.g., gradients, iridescent print, intaglio print,” or “transparent regions.” Ex-1007, 9:28-34. A POSITA would have found it obvious to also incorporate an ink into Schröder’s moldable filler material in order to achieve particular optical properties that increases a value of transmitted infrared light intensity divided by transmitted visible light intensity.

388. This limitation is also taught by Yuen for the reasons discussed in Ground 1 (Section VIII.A.2.j). Yuen teaches that the moldable filler material comprises an ink that allows preferential transmission of infrared light such that the ink increases a value of transmitted infrared light intensity divided by transmitted visible light intensity. In particular, Yuen teaches that “the circuitry related to emitting and receiving light may be disposed in the interior of the device housing and underneath a plastic or glass layer (for example, *painted with infrared ink*) or an infrared lens *which permits infrared light to pass but not light in the human visual spectrum.*” Ex-1006, 10:63-11:1. As a result, “the light transmission is

invisible to the human eye.” Ex-1006, 11:1-2. In effect, a POSITA would have understood that the infrared ink taught by Yuen increases the ratio of transmitted infrared light intensity to transmitted visible light intensity, as claimed, because it permits infrared light to pass through but not light that is visible to the human eye, thus decreasing the denominator and increasing the ratio.

389. As I explained in the Technology Background Section (*see* Section V), U.S. Patent No. 6,745,061 to Hicks 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.”).

390. 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 is toleranced 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 carried 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.”).

391. A POSITA would have been motivated to combine the teachings of Schröder and Yuen and would have had a reasonable expectation of success in doing so for the same reasons discussed in Section VIII.D.1.

IX. CONCLUSION

392. For the reasons set forth above, I believe that Claims 1-12 of the '833 Patent is unpatentable in view of the prior art.

393. 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.

394. 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.

395. 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,
