

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

OURARING INC.,
Patent Owner.

Case No. IPR2024-01079
U.S. Patent No. 10,281,953

**DECLARATION OF BRIAN W. ANTHONY
IN SUPPORT OF PETITION FOR INTER PARTES REVIEW
OF U.S. PATENT NO. 10,281,953**

TABLE OF CONTENTS

	Page
I. INTRODUCTION	1
A. Qualifications.....	1
B. Materials Considered	7
II. LEGAL STANDARDS	12
A. Anticipation	13
B. Obviousness.....	14
C. Level of Ordinary Skill in the Art	17
D. Claim Construction	18
III. SUMMARY OF GROUNDS.....	19
IV. THE '953 PATENT	20
A. Overview of the '953 Patent	20
B. Prosecution History of the '953 Patent.....	22
V. TECHNOLOGY BACKGROUND.....	22
A. Wearable Electronic Devices Were Known	22
1. Photoplethysmography (PPG) sensors were well known.....	27
2. Beer's Law.....	29
3. Optical properties of human tissue	31
4. Pulse oximetry and oxygen saturation (SpO ₂)	32
5. Transmission of light as compared to the reflection of light	33
6. Multiple LEDs have been commonly used for biometric monitoring	35
7. Separation distance between LEDs and the photodiode is a design consideration for the quality of the acquired data	36
B. Wearable Electronic Device Arrangements.....	37
1. Wearable devices having inner and outer surfaces were known.....	37
2. Various ways to assemble electronic parts within	

TABLE OF CONTENTS
(continued)

	Page
structural cavities were known	38
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 or potting 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 of Sensors and Other Electronic Components Was Known.....	78
E. Gesture Recognition Sensors and Techniques Were Known	84
2. Hardware for gesture recognition was well-known	84
3. Gesture recognition techniques were well-known	90
4. Multiple instances and training mode.....	96
VI. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS.....	102
A. Sun (Ex-1015).....	102
B. Asami (U.S. Patent Publication No. 2010/0219989) (Ex-1014)	104
A. Bress (Ex-1016).....	106
VII. CLAIM CONSTRUCTION	107
VIII. DETAILED EXPLANATION OF THE UNPATENTABILITY GROUNDS.....	108

TABLE OF CONTENTS
(continued)

	Page
A. Ground 1: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun.....	108
1. Independent Claims 16 and 30	108
a. Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and.....	108
b. Element 16[pre(2)]: the wearable computing device comprising at least one sensor module having at least one sensor, at least one processor, and at least one transceiver; the method comprising / Element 30[pre(2)]: including a sensor module having a sensor and a transceiver, which instructions, when executed by the processor, causes the processor to perform operations comprising	110
c. Elements 16[a]/30[a]: obtaining, by the sensor of the sensor module, sensor data indicating a motion of the finger or a hand adjoined to the finger wearing the wearable computing device;	113
d. Elements 16[b]/[30[b]]: comparing, by [one of the at least one] processor[s], the obtained sensor data to a predetermined pattern of motion;	115
e. Elements 16[c]/[30[c]]: determining, by [one of the at least one] processor[s], whether the obtained sensor data matches a predetermined pattern;	116

TABLE OF CONTENTS

(continued)

	Page
f. Elements 16[d]/[30[d]]: determining, by [one of the at least one] processor[s], a characteristic of an activity of the user of the wearable computing device when the obtained sensor data matches the predetermined pattern; and..... g. Element 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.	119 120
2. Dependent Claims 17/[31]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: determining that the sensor data matches the predetermined pattern based at least in part on a completion of the activity.....	125
3. Dependent Claims 18/[32]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising:] determining that the sensor data matches the predetermined pattern based at least in part on a start of the activity.....	127
4. Dependent Claim 20: The method of claim 16, wherein the sensor data further comprises an axial rotation measurement.....	128
5. Dependent Claims 21/[33]: The method of claim 16/[The non-transitory computer readable storage medium of claim 30], wherein the [at least one] sensor module comprises one or more of a light sensor, a gyroscope, and/or a magnetometer, and the sensor data further comprises a measurement from one or more of the light sensor, a gyroscope, and/or a magnetometer.	128
6. Dependent Claim 23 and 34.....	130

TABLE OF CONTENTS
(continued)

	Page
a. Elements 23[pre/a]/[34[pre/a]]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: converting the sensor data into a series of samples;	130
b. Elements 23[b]/34[b]: comparing the series of samples to the predetermined pattern; and	132
c. Elements 23[c]/34[c]: determining that the sensor data matches the predetermined pattern if the series of samples matches the predetermined pattern.....	134
7. Dependent Claims 24/[35]: The method of claim 23, wherein/[The non-transitory computer readable storage medium of claim 34, wherein the processor further executes an operation comprising:] the comparing between the series of samples and the predetermined pattern is determined by a recognition technique.	134
8. Dependent Claim 37	136
a. Elements 37[pre/a]: The non-transitory computer readable storage medium of claim 30, wherein the processor further executes operations comprising: converting the sensor data into at least one direction vector;	136
b. Element 37[b]: detecting a characteristic of an orientation changes of the wearable computing device based at least in part on the at least one direction vector;	137
c. Element 37[c]: comparing the characteristics of the detected orientation changes to the predetermined pattern; and	137
d. Element 37[d]: determining whether the sensor data matches the predetermined pattern.	138

TABLE OF CONTENTS

(continued)

	Page
B. Ground 2: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun in View of Bress	139
1. A POSITA would have been motivated to combine Sun’s and Bress’s teachings and would have had a reasonable expectation of success.....	139
2. Independent Claims 16 and 30	142
a. Element 16 <pre>(1)</pre> : A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30 <pre>(1)</pre> : A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and.....	142
b. Elements 16 <pre>(2)</pre> / <pre>30</pre> <pre>(2)</pre>	143
c. Elements 16 <pre>[a]</pre> / <pre>30</pre> <pre>[a]</pre>	143
d. Elements 16 <pre>[b]</pre> / <pre>30</pre> <pre>[b]</pre>	143
e. Elements 16 <pre>[c]</pre> / <pre>30</pre> <pre>[c]</pre>	143
f. Elements 16 <pre>[d]</pre> / <pre>30</pre> <pre>[d]</pre>	144
g. Elements 16 <pre>[e]</pre> / <pre>30</pre> <pre>[e]</pre> : activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.	144
3. Dependent Claims 17/ <pre>31</pre>	146
4. Dependent Claims 18/ <pre>32</pre>	146
5. Dependent Claim 20	146
6. Dependent Claims 21/ <pre>33</pre>	146
7. Dependent Claim 23 and 34.....	146

TABLE OF CONTENTS

(continued)

	Page
a. Elements 23[pre/a]/34[pre/a].....	146
a. Elements 23[b]/34[b]	146
a. Elements 23[c]/34[c].....	147
8. Dependent Claims 24 / 35	147
9. Dependent Claim 37	147
a. Elements 37[pre/a].....	147
a. Element 37[b]	147
a. Element 37[c]	147
a. Element 37[d]	147
C. Ground 3: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun in View of Asami	147
1. A POSITA would have been motivated to combine Sun’s and Asami’s teachings and would have had a reasonable expectation of success.....	148
2. Independent Claims 16 and 30	149
a. Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and.....	149
b. Elements 16[pre(2)]/30[pre(2)]:	150
c. Elements 16[a]/30[a].....	151
d. Elements 16[b]/30[b]	151
e. Elements 16[c]/30[c].....	151
f. Elements 16[d]/30[d]	151

TABLE OF CONTENTS
(continued)

	Page
g. Elements 16[e]/30[e].....	151
3. Dependent Claims 17/31	151
4. Dependent Claims 18/32	151
5. Dependent Claim 20	152
6. Dependent Claims 21/33	152
7. Dependent Claim 23 and 34	152
a. Elements 23[pre/a]/[34[pre/a]	152
b. Elements 23[b]/34[b]	152
c. Elements 23[c]/34[c].....	152
8. Dependent Claims 24/35	152
9. Dependent Claim 37	153
a. Elements 37[pre/a].....	153
b. Element 37[b]	153
c. Element 37[c]	153
d. Element 37[d]	153
D. Ground 4: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun in View of Asami and Further in View of Bress.....	153
1. A POSITA would have been motivated to combine Sun- Asami's teachings with Bress's teachings and would have had a reasonable expectation of success.....	153
2. Independent Claims 16 and 30	155

TABLE OF CONTENTS

(continued)

Page

a.	Element 16 <pre>(1)</pre> : A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30 <pre>(1)</pre> : A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and.....	155
b.	Element 16 <pre>(2)</pre> /30 <pre>(2)</pre> :	156
c.	Elements 16[a]/30[a].....	156
d.	Elements 16[b]/[30[b]].....	157
e.	Elements 16[c]/[30[c]]	157
f.	Elements 16[d]/[30[d]].....	157
g.	Element 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.	157
3.	Dependent Claims 17/31	158
4.	Dependent Claims 18/32	158
5.	Dependent Claim 20	159
6.	Dependent Claims 21/33	159
7.	Dependent Claim 23 and 34	159
a.	Elements 23 <pre>(pre/a)</pre> /[34 <pre>(pre/a)</pre>]	159
b.	Elements 23[b]/34[b]	159
c.	Elements 23[c]/34[c].....	159
8.	Dependent Claims 24/35	159
9.	Dependent Claim 37	159

TABLE OF CONTENTS

(continued)

	Page
a. Elements 37[pre/a]	160
b. Element 37[b]	160
c. Element 37[c]	160
d. Element 37[d]	160
E. Ground 5: Claims 16-18, 23-24, 30-32, and 34-35 Are Obvious Over Asami in View of Bress	160
1. A POSITA would have been motivated to combine Asami's and Bress's teachings and would have had a reasonable expectation of success	160
2. Independent Claims 16 and 30	162
a. Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and.....	162
a. Element 16[pre(2)]: the wearable computing device comprising at least one sensor module having at least one sensor, at least one processor, and at least one transceiver; the method comprising / Element 30[pre(2)]: including a sensor module having a sensor and a transciever, which instructions, when executed by the processor, causes the processor to perform operations comprising:.....	163
b. Elements 16[a]/30[a]: obtaining, by the sensor of the sensor module, sensor data indicating a motion of the finger or a hand adjoined to the finger wearing the wearable computing device;	165

TABLE OF CONTENTS

(continued)

	Page
c. Elements 16[b]/[30[b]]: comparing, by [one of the at least one] processor[s], the obtained sensor data to a predetermined pattern of motion;	167
d. Elements 16[c]/[30[c]]: determining, by [one of the at least one] processor[s], whether the obtained sensor data matches a predetermined pattern;	168
e. Elements 16[d]/[30[d]]: determining, by [one of the at least one] processor[s], a characteristic of an activity of the user of the wearable computing device when the obtained sensor data matches the predetermined pattern; and.....	169
f. Elements 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.	172
3. Dependent Claims 17/[31]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: determining that the sensor data matches the predetermined pattern based at least in part on a completion of the activity.....	175
4. Dependent Claims 18/[32]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising:] determining that the sensor data matches the predetermined pattern based at least in part on a start of the activity.....	176
5. Dependent Claim 20: The method of claim 16, wherein the sensor data further comprises an axial rotation measurement.....	178
6. Dependent Claims 21/[33]: The method of claim 16/[The non-transitory computer readable storage medium of claim 30], wherein the [at least one] sensor module	

TABLE OF CONTENTS
(continued)

	Page
comprises one or more of a light sensor, a gyroscope, and/or a magnetometer, and the sensor data further comprises a measurement from one or more of the light sensor, a gyroscope, and/or a magnetometer.	179
7. Dependent Claims 23 and 34	181
a. Elements 23[pre/a]/[34[pre/a]]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: converting the sensor data into a series of samples;	181
b. Elements 23[b]/34[b]: comparing the series of samples to the predetermined pattern; and	182
c. Elements 23[c]/34[c]: determining that the sensor data matches the predetermined pattern if the series of samples matches the predetermined pattern.....	183
8. Dependent Claims 24 and 35: The method of claim 23, wherein/[The non-transitory computer readable storage medium of claim 34, wherein the processor further executes an operation comprising:] the comparing between the series of samples and the predetermined pattern is determined by a recognition technique.	183
IX. CONCLUSION	184

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. 10,281,953 (“the ’953 Patent”) (Ex-1001), currently assigned to Ouraring Inc. (“Patent Owner” or “PO”).

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

3. I have been asked to provide my independent analysis of the ’953 Patent in light of the prior art patents and publications cited below. I have also been asked to consider the state of the art and prior art available as of November 29, 2013. Based on the prior art discussed in this Declaration, it is my opinion that Claims 16-18, 20-21, 23-24, 30-35, and 37 of the ’953 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 a decade prior to the ’953 Patent’s earliest possible priority date—addressed the same system issues as those described and claimed in the ’953 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 '953 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 '953 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. I've developed human-in-the-loop free-hand systems that precisely measure gestures and maintain the relative orientation and position of free-hand probes with respect to the patient using a combination of accelerometers, gyroscopes, and electromagnetic emitters. Our systems ensure accuracy and stability in motions and gestures and forces, enhancing the quality of diagnostic and therapeutic procedures. Additionally, we have created gesture measurement and gesture control platforms that can simultaneously image and perform precise, operator-controlled actions on patient tissue. These platforms are designed to compensate for both patient and doctor variability, ensuring consistent and accurate results even in dynamic clinical environments. My experience with these devices is directly applicable to the technology in the '953 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 '953 Patent. I teach or have taught courses in Manufacturing Engineering, Smart Manufacturing, Industrial Internet of Things, all pertinent subject matter to the '953 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 '953 Patent. We develop polymer-based devices and optical sensors to and use noninvasively monitoring techniques soft flexible materials 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 '953 Patent, such as:

- Ranger, Bryan J.; Feigin, Micha; Pestrov, Nikita; Zhang, Xiang; Lempitsky, Victor; Herr, Hugh M.; Anthony, Brian W., “Motion compensation in a tomographic ultrasound imaging system: Toward volumetric scans of a limb for prosthetic socket design,” 2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 7204-7207;
- Shih-Yu Sun, Matthew Gilbertson, and Brian W. Anthony, “Probe Localization for Freehand 3D Ultrasound by Tracking Skin Features,” Book Section, Medical Image Computing and Computer-Assisted Intervention, MICCAI 2014, Springer, 2014, Vol. 8674. Lecture Notes in Computer Science, pp. 365-372;
- J. H. Lee, C. M. Schoellhammer, G. Traverso, D. Blankschtein, R. Langer, K. E. Thomenius, D. S. Boning, B. W. Anthony, “Towards Wireless Capsule Endoscopic Ultrasound (WCEU),” IEEE International Ultrasonics Symposium (IUS), Chicago, IL, 2014, pp. 734-737; and
- Zakrzewski, A., Anthony, B. W., “Quantitative Elastography and its Application to Blood Pressure Estimation: Theoretical and

Experimental Results,” 2013 IEEE Engineering in Medicine and
Biology Society (EMBC), pp. 1136-1139.

B. Materials Considered

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

Ex. No.	Description
Ex-1001	U.S. Patent No. 10,281,953 (“the ’953 Patent”)
Ex-1002	Declaration of Dr. Brian W. Anthony
Ex-1003	Curriculum Vitae of Dr. Brian W. Anthony
Ex-1004	Prosecution History of the ’953 Patent (Application No. 15/854,783)
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. 2014/0244009 (“Mestas”)
Ex-1011	U.S. Provisional Patent App. No. 61/768,279 to Mestas
Ex-1012	INTENTIONALLY LEFT BLANK

Ex. No.	Description
Ex-1013	U.S. Patent Publication No. 20120218184 to Wissmar (“Wissmar”)
Ex-1014	U.S. Patent Publication No. 2010/0219989 to Asami (“Asami”)
Ex-1015	U.S. Patent Publication No. 2011/0080339 to Sun (“Sun”)
Ex-1016	U.S. Patent No. 9,218,058 to Bress (“Bress”)
Ex-1017	U.S. Patent No. 8,031,172 to Kruse (“Kruse”)
Ex-1018	INTENTIONALLY LEFT BLANK
Ex-1019	INTENTIONALLY LEFT BLANK
Ex-1020	Claim Mapping Table
Ex-1021	INTENTIONALLY LEFT BLANK
Ex-1022	INTENTIONALLY LEFT BLANK
Ex-1023	INTENTIONALLY LEFT BLANK
Ex-1024	U.S. Patent No. 4,830,014 to Goodman (“Goodman”)
Ex-1025	U.S. Patent No. 6,745,061 to Hicks (“Hicks”)
Ex-1026	U.S. Patent No. 7,190,986 to Hannula (“Hannula”)
Ex-1027	Volker Konig et al., Reflectance Pulse Oximetry – Principles and Obstetric Application in the Zurich System, 14 Journal of Clinical Monitoring (Aug. 1998) (“Konig”)
Ex-1028	U.S. Patent No. 6,608,562 to Kimura (“Kimura”)
Ex-1029	Kevin K. Tremper et al., Pulse Oximetry, 70 Journal of American Society of Anesthesiologists, Inc. (Jan. 1989) (“Tremper”)
Ex-1030	Y. Mendelson et al., A Wearable Reflectance Pulse Oximeter for Remote Physiological Monitoring, Proceedings of 28 th IEEE EMBS Annual Int’l Conference (Aug. 30-Sept. 3, 2006) (“Mendelson 2006”)

Ex. No.	Description
Ex-1031	Sokwoo Rhee et al., Artifact-Resistant, Power-Efficient Design of Finger-Ring Plethysmographic Sensors Part I: Design and Analysis, IEEE (2000) (“Rhee 2000 Part I”)
Ex-1032	Sokwoo Rhee et al., Artifact-Resistant, Power-Efficient Design of Finger-Ring Plethysmographic Sensors Part II: Prototyping and Benchmarking, IEEE Proceedings of 22 nd Annual EMBS Int’l Conference (July 23-28, 2000) (“Rhee 2000 Part II”)
Ex-1033	Sokwoo Rhee et al., Artifact-Resistant Power-Efficient Design of Finger-Ring Plethysmographic Sensors, 48 IEEE Transactions of Biomedical Engineering (July 2001) (“Rhee 2001”)
Ex-1034	U.S. Patent No. 6,699,199 to Asada (“Asada ’199”)
Ex-1035	Sokwoo Rhee, Design and Analysis of Artifact-Resistive Finger Photoplethysmographic Sensors for Vital Sign Monitoring, MIT (June 2000) (“Rhee Thesis 2000”)
Ex-1036	C.T. Olofson et al., <i>Machining of Titanium Alloys</i> (1965) (“Olofson”)
Ex-1037	Asada et al., Mobile Monitoring with Wearable Photoplethysmographic Biosensors, IEEE Eng’g in Medicine & Biology Magazine 28 (May-June 2003) (“Asada 2003”)
Ex-1038	Denisse Castaneda et al., <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. No.	Description
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-1052	A. Petropoulos et al., “Flexible PCB-MEMS flow sensor,” Proc. Eurosensors XXVI, Sept. 2012 (“Petropoulos”)
Ex-1053	T. Sun et al., “Wireless Power Transfer for Medical Microsystems” 2013 (“Sun-Wireless”)
Ex-1054	U.S. Patent Pub. No. 2014/0187160 to Prencipe (“Prencipe”)
Ex-1055	H. Ardebili and M.G. Pecht, “Encapsulation Technologies for Electronic Applications” (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. No.	Description
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”)
Ex-1062	INTENTIONALLY LEFT BLANK
Ex-1063	INTENTIONALLY LEFT BLANK
Ex-1064	INTENTIONALLY LEFT BLANK
Ex-1065	INTENTIONALLY LEFT BLANK
Ex-1066	INTENTIONALLY LEFT BLANK
Ex-1067	Chao Chen and Carlos Pomalaza-Raez, Monitoring Human Movements at Home Using Wearable Wireless Sensors, Proceedings of ISMICT (2009) (“Chen 2”)
Ex-1068	Christoph Amma et al., Airwriting Recognition Using Wearable Motion Sensors, Proceedings of Augmented Human Conference, Megève, France (2010) (“Amma”)
Ex-1069	Yinghui Zhou et al., Analysis and Selection of Features for Gesture Recognition Based on a Micro Wearable Device, Int. J. Adv. Computer Sci. & Appls., Vol. 3 No. 1, 1-7 (2012) (“Zhou”)

Ex. No.	Description
Ex-1070	Taiwoo Park et al., E-Gesture: A Collaborative Architecture for Energy-efficient Gesture Recognition with Hand-worn Sensor and Mobile Devices, SenSys '11, Seattle, WA (2011) ("Park")
Ex-1071	Jun Rekimoto, GestureWrist and GesturePad: Unobtrusive Wearable Interaction Devices, Proc. 5th Int. Symposium on Wearable Computers (2001) ("Rekimoto")
Ex-1072	H. Ying et al., Automatic Step Detection in the Accelerometer Signal, 4th Int. Workshop on Wearable and Implantable body Sensor Networks, Springer (2007) ("Ying")
Ex-1073	Chun Zhu and Weihua Sheng, Wearable Sensor-Based Hand Gesture and Daily Activity Recognition for Robot-Assisted Living, IEEE Trans. Systems, Man, and Cybernetics, 41(3) (2011) ("Zhu")
Ex-1074	Jiayang Liu et al., uWave: Accelerometer-based Personalized Gesture Recognition and Its Applications, Pervasive and Mobile Computing 5(6), 657-75 (2009) ("Liu")
Ex-1075	Thomas Schlömer et al., Gesture Recognition With a Wii Controller, Proc. 2d Int. Conf. Tangible & Embedded interaction, Bonn, Germany (2008) ("Schlömer")
Ex-1076	Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, The MIT Press, Cambridge, Massachusetts (2012) ("Murphy")
Ex-1077	Paulo Trigueiros et al., A Comparison of Machine Learning Algorithms Applied to Hand Gesture Recognition, 7th Iberian Conf. Inf. Syst. & Techs. (2012) ("Trigueiros")

II. LEGAL STANDARDS

13. In forming my opinions and considering the subject matter of the '953 Patent and its claims in light of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is

summarized below

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

A. Anticipation

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

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

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

B. Obviousness

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

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

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

would have been obvious.

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

22. I understand that one may consider, e.g., whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order

to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a person of ordinary skill in the art.

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

24. I am not aware of any allegations by the named inventors of the '953 Patent or any assignee of the '953 Patent that any secondary considerations tend to rebut the obviousness of the '953 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 of November 29, 2013 (“POSITA”) would have had at least a four-year degree in electrical engineering, mechanical engineering, biomedical engineering, optical engineering, or related field of study, or equivalent experience, and at least two years’ experience in academia or industry studying or developing physiological monitoring devices such as non-invasive biosensors. A POSITA would have also been familiar with, for example, sensor system design, including inertial and other motion sensor system design, signal processing, and human-machine interfaces. 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 16-18, 20-21, 23-24, 30-35, and 37 of the '953 Patent. It is my opinion that the following grounds demonstrate that the challenged claims of the '953 Patent are invalid.

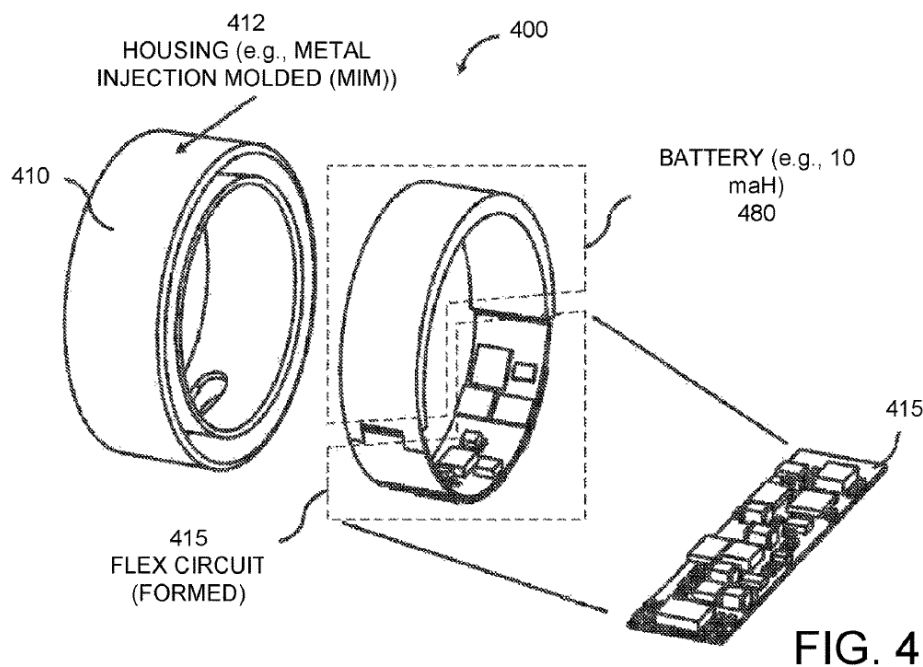
Ground	Summary
1	Claims 16-18, 20-21, 23-24, 30-35, and 37 are obvious over Sun (Ex-1015)
2	Claims 16-18, 20-21, 23-24, 30-35, and 37 are obvious over Sun in view of Bress (Ex-1016)

3	Claims 16-18, 20-21, 23-24, 30-35, and 37 are obvious over Sun in view of Asami (Ex-1014)
4	Claims 16-18, 20-21, 23-24, 30-35, and 37 are obvious over Sun in view of Asami in further view of Bress
5	Claims 16-18, 20-21, 23-24, and 30-35 are obvious over Asami in view of Bress

IV. THE '953 PATENT

A. Overview of the '953 Patent

The '953 Patent is generally directed to a wearable computing device, an example of which is shown in Figure 4, reproduced below.



35. The claims Petitioner challenges in this Petition are directed to a gesture recognition method and computer readable medium storing instructions for the wearable device to detect the motion of the user's finger or hand, compare that

motion with a predetermined pattern, and send a signal to an external device if the motion matches the pattern. Ex-1001, Cls. 16, 30. Further, the claims recite that the wearable device is “in the form factor of a ring for being worn around the finger of a user.” *Id.* An example of using the device to communicate with and control an external device through predetermined gestures with the finger-worn device is shown in Fig. 25, reproduced annotated¹ below.

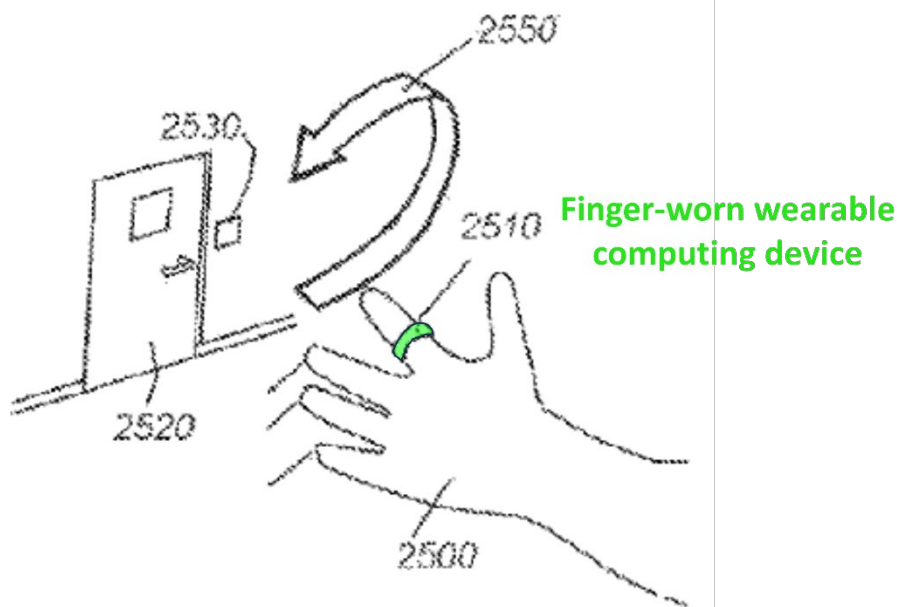


FIG. 25

36. The '953 Patent specification states that “many current wearable electronics are bulky and can be intrusive,” and describes the patent’s purported

¹ Throughout, emphasis and annotations are added unless otherwise specified.

innovation as “overcom[ing] the disadvantages of the prior art by providing a wearable computing device (WCD) in the shape of a ring.” *Id.*, 2:33-43. The device components include a processor module, sensor modules, power module, communication module, and memory. *Id.*, 7:43-46. The device sensors may include, e.g., “accelerometers...or other suitable sensors (e.g., for gesture recognition).” *Id.*, 9:14-19.

37. As I explain in detail below, the challenged ’953 Patent claims are obvious in view of the prior art.

B. Prosecution History of the ’953 Patent

38. The ’953 Patent issued from Application No. 15/854,783, filed December 27, 2017. It claims priority through a continuation-in-part and a continuation to Application No. 14/556,062, filed November 28, 2014, now U.S. Patent No. 9,582,034. Ex-1001 at 1-2. The ’953 Patent further claims priority to Provisional Application Nos. 62/006,835, filed June 2, 2014, and 61/910,201, filed November 29, 2013. *Id.* at 2. I apply the earliest alleged priority date of the ’953 Patent for my analysis herein, which I understand is November 29, 2013.

39. I understand that the Petition presents arguments and prior art not considered during prosecution of the ’953 Patent.

V. TECHNOLOGY BACKGROUND

A. Wearable Electronic Devices Were Known

40. Wearable electronic devices, along with the various design challenges

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

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).

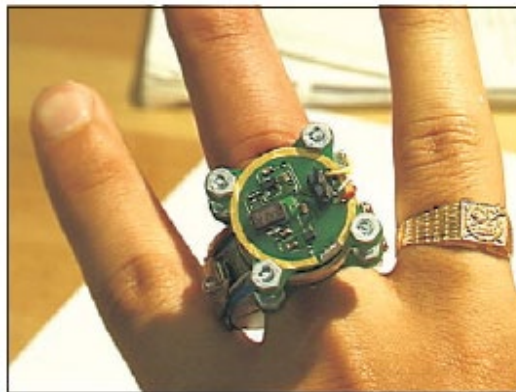


Fig. 9. First prototype ring sensor with RF transmitter powered by a coin-size cell battery.

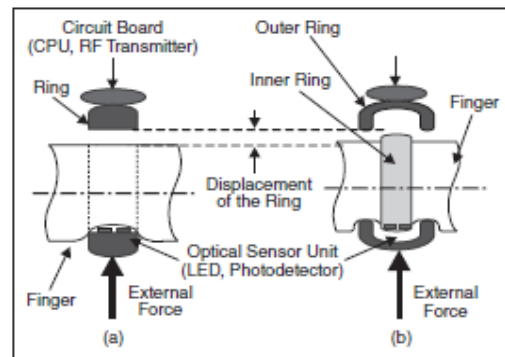


Fig. 10. Dislocation of ring sensors due to external load. (a) Traditional single-body design under external force. (b) New isolating double ring sensor under external force [31].

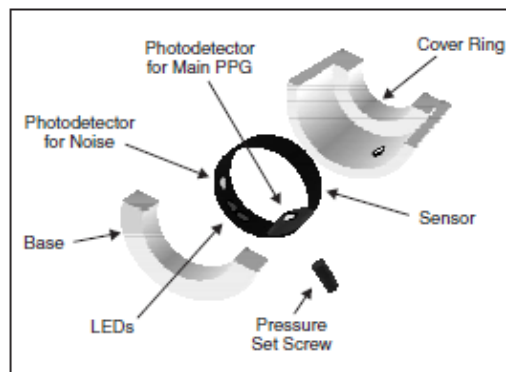


Fig. 15. The schematic of the Prototype C ring sensor.

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.*

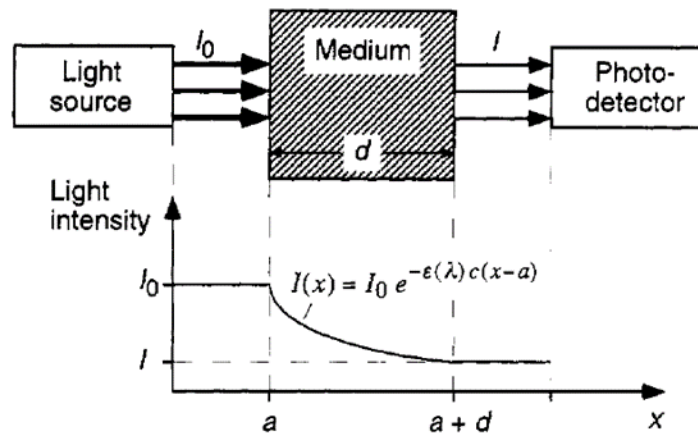


Figure 4.1 Beer's law: Incident light of intensity I_0 travels the distance a from a light source to the medium without being absorbed in the air. The light intensity decreases exponentially with distance in the absorbing medium. The intensity of the transmitted light I is determined by Beer's law. It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

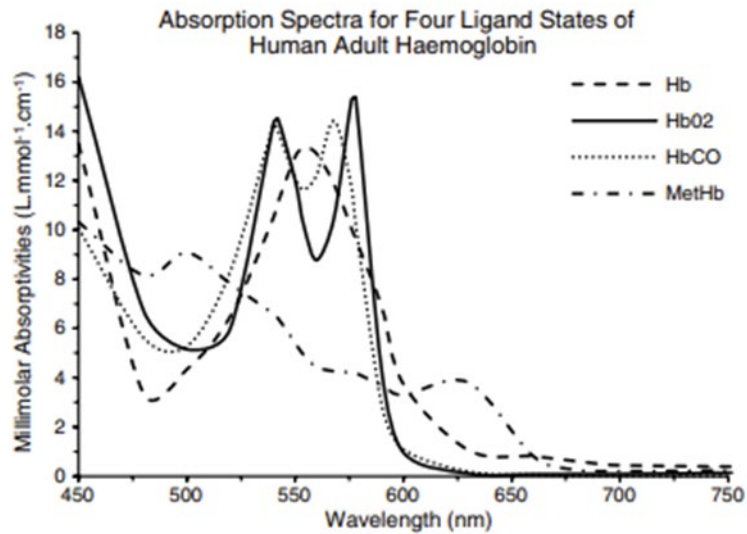


Fig. 1 Absorption spectra of deoxyhemoglobin (Hb), oxyhemoglobin (HbO₂), carboxyhemoglobin (HbCO), and methemoglobin (MetHb) in the visible region, from Ref. 27.

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 (SpO_2) 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 SpO_2 , 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 SpO_2 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 SpO_2 , are designed to operate at the macroscale or sensor scale (emitter and detector scale) and are generally described as operating in two modes: transmission mode and reflection mode.

Transmission Mode: In this mode, the light emitter and the detector are generally

positioned on opposite sides of the tissue. Light from the emitter penetrates the tissue and takes a general path that passes through the tissue to the opposite side of the tissue, and the detector measures the light that has traversed the tissue.

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

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

63. Reflectance and transmission are best considered as practical design and manufacturing terms. They describe the physical arrangement of the emitters and detectors rather than any fundamental difference in the measurement process. Both geometries are used to measure the diffused absorption of light through a blood-perfused tissue bed, providing essential information about blood oxygen saturation levels.

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

6. Multiple LEDs have been commonly used for biometric monitoring

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

66. U.S. Patent Publication No. 2006/0211924 to Dalke et al. (“Dalke”) also discloses the use of multiple spaced-apart LEDs operating at various

wavelengths and/or intensities. Ex-1040. Dalke states “there can be any number of LED groups and any number of LEDs within a group” and further that such LEDs “may be grouped according to output intensity or wavelength or both.” Ex-1040 ¶ 75.

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

67. From a system design and performance perspective, determining the ideal separation distance between the LEDs and photodiode is important. To enhance the quality of the plethysmogram signal one method includes placing the photodiode close to the LEDs. Ex-1041 (Guidelines to enhancing), 0005. However, if the photodiode is too close to the LEDs, the photodiode becomes saturated by measurements that do not relate to the heart signal of the user. *Id.* To have a constant LED intensity, “the total light detected by the photodiode decreases roughly exponentially as the radial distance between the LEDs and the photodiode is increased.” *Id.* Thus, placing the photodiode farther apart from the LEDs can result in a plethysmogram with a larger signal that relates to the heart signals of the user. *Id.* As an example, U.S. Patent No. 4,880,304 to Jaeb et al. (“Jaeb”) uses this method and resolves the problem of low signal strength by placing its LEDs 16 and 18 in a radial pattern around detector 20 that detects the light of the LEDs. Ex-1042, 5:6-8.

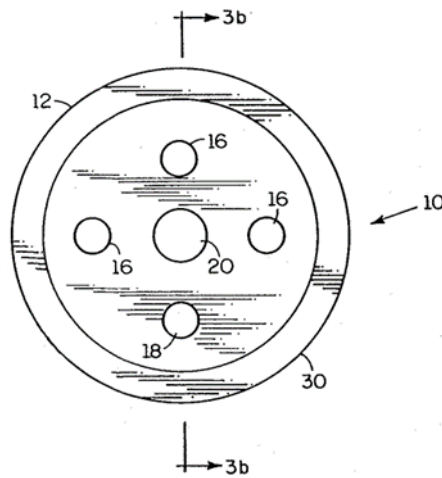


FIG. 3a

B. Wearable Electronic Device Arrangements

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

1. Wearable devices having inner and outer surfaces were known

69. Finger-ring structures having inner and outer surfaces with electronics housed inside within a cavity were known. For example, Rhee's thesis and papers teach a finger-ring sensor having inner and outer surfaces. Specifically, Rhee teaches, as shown in Figure 1 (Rhee 2000 Part II) and Figure 3 (Rhee 2001) below, that an "inner ring floats inside the outer ring" such that "[w]hen a patient wears the

ring, both rings are put on the same finger.” And, “[s]ince the outer ring covers the inner ring, the external force is born by the outer ring and does not directly act on the inner ring.” Ex-1032, 2796 (Rhee 2000 Part II); Ex-1033, 799 (Rhee 2001); Ex-1035, 68 (Rhee Thesis 2000) (same).

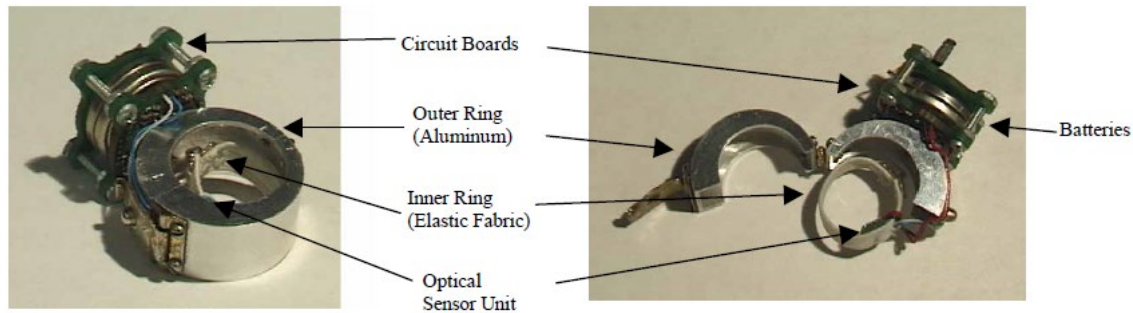


Figure 1 : Isolating ring sensor designed for motion artifact minimization

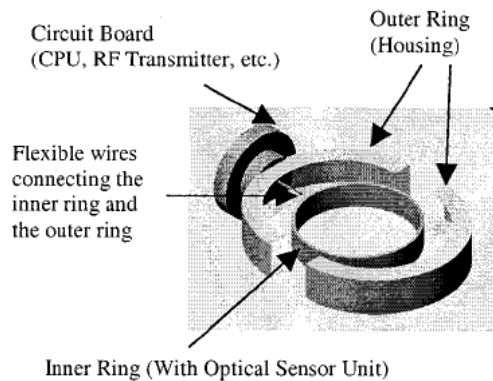


Fig. 3. Construction of isolating ring.

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

70. The formation of cavities, whether by single-structure formation or multi-structure assembly techniques, is essential for integrating electronic components, cabling, batteries, PCBs, and assemblies into the interiors and exteriors of mechanical surfaces, structures, and frames. This is crucial in the manufacturing

of electromechanical devices ranging from cars and computer interface devices to phones, toys, watches, electronic medical devices, and other modern battery or wall-power operated devices. Manufacturing and assembly approaches vary based on tooling sizes, costs, and complexities.

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

72. Creating a mechanical part from raw material involves bulk material removal, forming cavities or holes, and finishing to meet specifications. Techniques like milling, drilling, and EDM are commonly used 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.

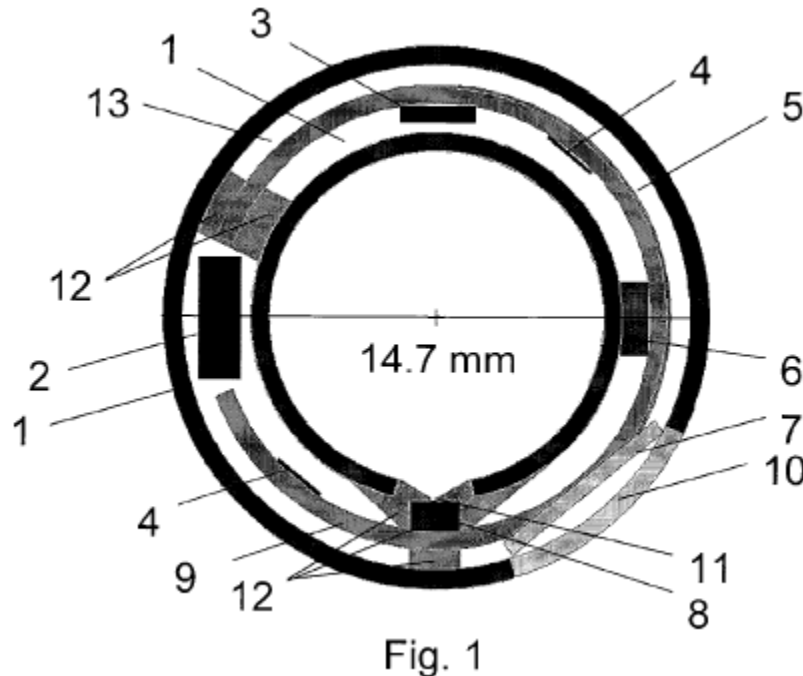
74. Common Techniques include:

- 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. 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

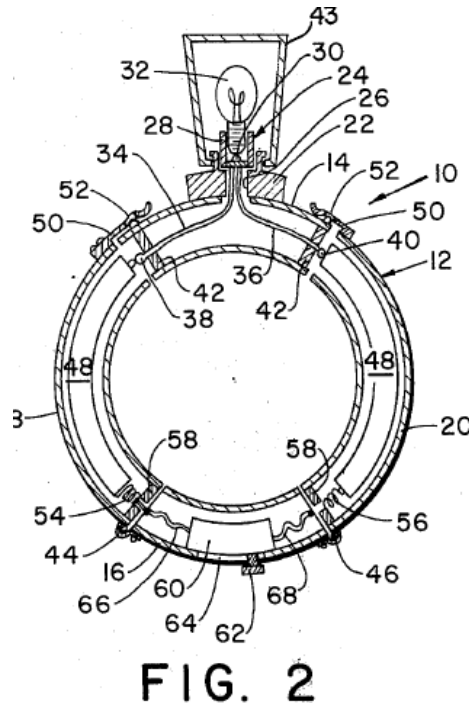
silver (Ag), enclosing the major parts of the finger ring structure geometrically described as radially furthest away from the toroids centre, and (ii). 1 b, made of a titanium compound (Ti, TiW), being the metal enclosing facing the inner parts of the finger ring structure.” *Id.* ¶73. As shown below 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.



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-

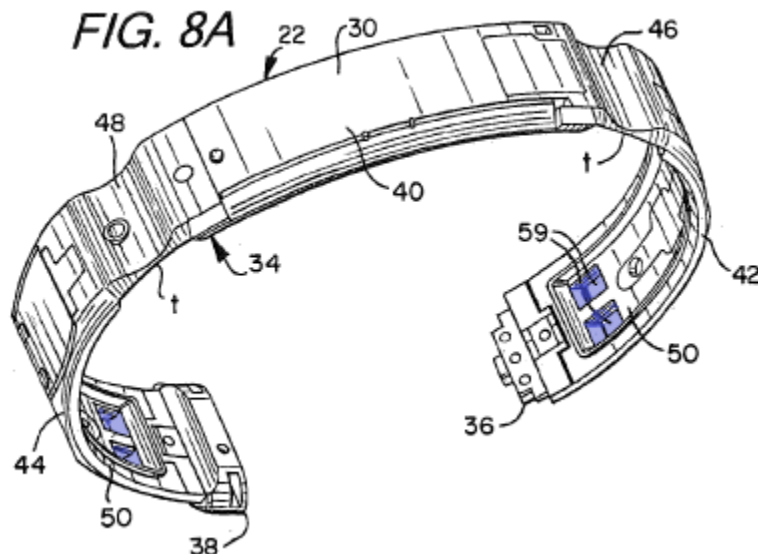
1060, 2:56-57.

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.



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 structural cavity by, for example,

injection molding, was well known by 2013. *See, e.g.*, Ex-1055, Ex-1056, Ex-1057, Ex-1058, and Ex-1059. I discuss this in more detail below in Section V.C.

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

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

conditions.” Ex-1031, 1 (Rhee 2000 Part I); Ex-1032, 2796 (Rhee 2000 Part II) (“The basic circuit configuration of the ring sensor is a standard photoplethysmographic circuit combined with a wireless transmitter. There are a single photodiode and LEDs of two different wavelengths, red and near infrared, involved in the circuit. ... The two channels of digital signals are transmitted via a RF transmitter. ... “[T]he whole system is designed and operated for low-power consumption. ... Each component has to be selected for low-power consumption and the whole system must be operated for minimum power consumption. The microprocessor coordinates the whole operation so that reliable measurement is performed with minimum power. ... The main circuit board and batteries, which are heavy and bulky in comparison to the sensor unit, sit on the outer ring.”); Ex-1033, 796-97, 799, Fig. 1 (Rhee 2001) (same); Ex-1035, 14, 21-22, 68 (Rhee Thesis 2000) (same).

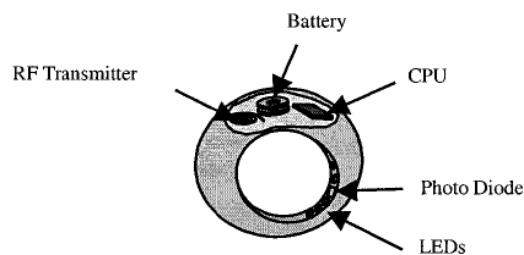


Fig. 1. Conceptual diagram of the ring sensor.

83. Moreover, Harry Asada and his MIT team by 2003 developed a finger-ring prototype having an “optical sensor unit, analog and digital processing units, and an RF transmitter, all of which are encapsulated in a compact body and powered

by a tiny cell battery used for wristwatches”; and a PIC microcomputer for performing device controls and signal processing including “LED modulation, data acquisition, filtering, and bi-directional RF communication.” Ex-1037, 34 (Asada 2003); *see also* Ex-1034, 3:12-21 (Asada ’199) (“Referring now to FIG. 2, a cross-section is shown of finger ring sensor 20 as worn on finger 22 of a patient. In preferred embodiments of the invention, a sensor band 21 is worn in direct contact with the finger and holds one or more Detector S2 and 26, against the skin of the finger. sensor band 21 is encompassed by base ring 23 which, in turn, is encompassed by cover ring 25 which supports circuit 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

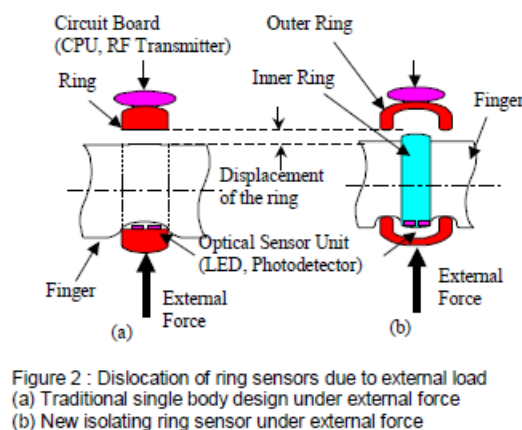
85. A POSITA would have understood by 2013 that electronics should be attached to a surface in the device and that where that attachment occurs (for example, at the top or bottom of a cavity) would have been a matter of design choice.

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 their 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

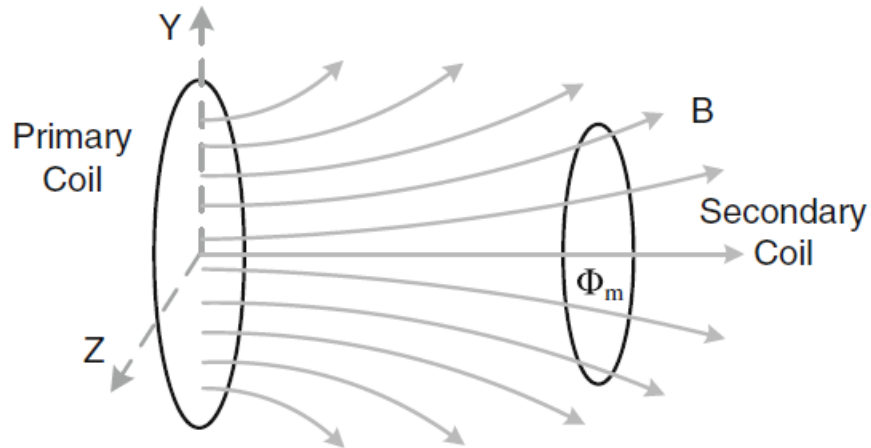
secured to so that there is “little to no gap between the skin side of the device and the juxtaposed surface of the skin of the user.” Ex-1006, 12:24-42 (Yuen). Similarly, U.S. Patent No. 10,303,867 to Schröder teaches a flexible PCB, but teaching that electronics such as antenna coil and a chip module 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-Wireless). By 2013 wireless power transfer was used either for "real-time energy" or "to charge batteries" in biomedical devices. *Id.*, 140 (Sun-Wireless). 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-Wireless). 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-Wireless). As Sun further explains, "[t]he most well-known power antenna for biomedical applications is the magnetic inductive coil." *Id.*, 42 (Sun-Wireless).

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-Wireless). 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 or potting material to cover electronics was known

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

97. By 2013, injection molding was "the most popular method for producing plastic products because of its high productivity and the manufacturability for making various complex shapes." Ex-1056, 51 (Ciofu). The "[i]njection process

is a cyclical process, during which succession occurs following operations: dosing of plastic material; heating and melting the plastic inside the cylinder; closing the mold; placing plastic material inside the mold cavity under pressure; melt solidification and cooling; mold opening; elimination product injected.” Ex-1056, 52 (Ciofu). Moreover, “[q]uality parameters (responses) are usually associated with evaluating the replication fidelity of the processes by completely filling the mould cavity.” Ex-1056, 55 (Ciofu), 57-57 (“feature engineering that refers to filling cavities is influenced by the part geometry, size and position of point size and shape filling and filling channels”); *see also, e.g.*, Ex-1058, 61 (Sakai) (“Plastic packaging for semiconductor products such as integrated circuits (ICs) has been commercially made by means of a transfer molding method using epoxy resin.”), 65 (applying “a quantitative analysis for molten polymer filling behavior in the cavities using a mold-filling simulation program commercially available such as Mold Flow”), 66 (“Figure 11 shows the experimental results using the 16-cavity side gate cold-runner system”), Fig. 11; Ex-1059, 10 (Teh) (“Figure 1 illustrates an example of such injection moulded thermoplastic parts with an embedded electronic subassembly. This proposed encapsulation technology adapts conventional techniques of thermoplastic injection moulding and electronic printed wiring board (PWB) assembly in order to achieve economical efficiency and manufacturing viability.”), 11 (“As shown in Figure 2, injection moulding can be briefly described as a cyclic

process of forming plastic into a pre-determined geometry by forcing high-temperature plasticized or molten polymer resin under an injection pressure into a specially shaped cavity (mould).”), Figs. 1-2.

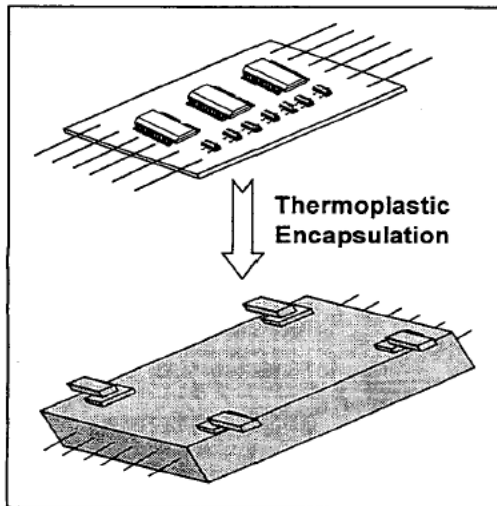


Figure 1. Illustration of the electronic overmoulding

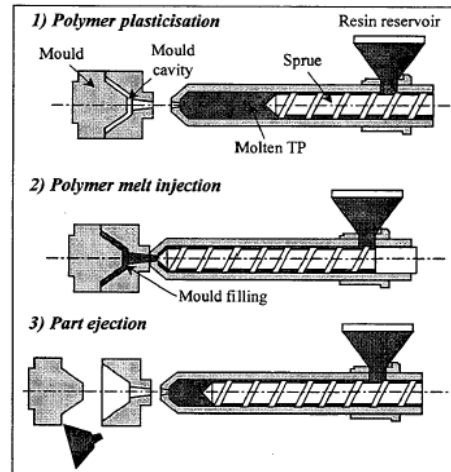


Figure 2. Schematic diagram of injection moulding

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

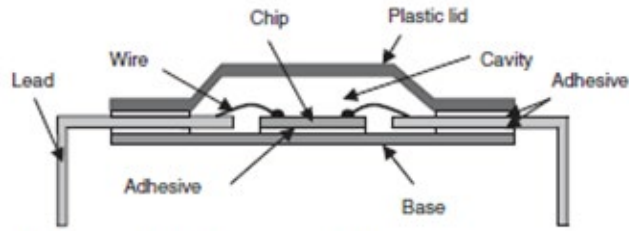


Figure 1.5 A pre-molded plastic package [9].

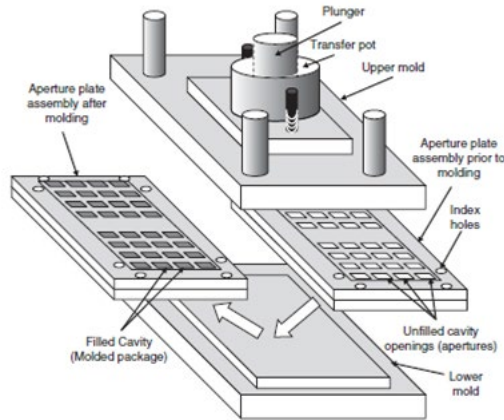


Figure 3.4 Aperture-plate (or cavity plate) molding setup [3].

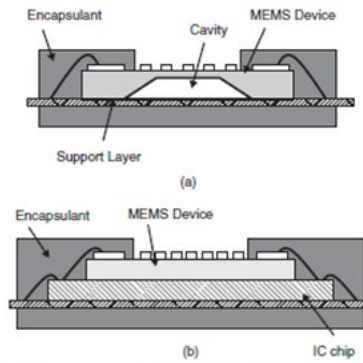


Figure 8.12 Plastic-encapsulated MEMS device package designs from Industrial Technology Research Institute: (a) MEMS device with a cavity; (b) 3D package with a MEMS device stacked on an IC chip [21].

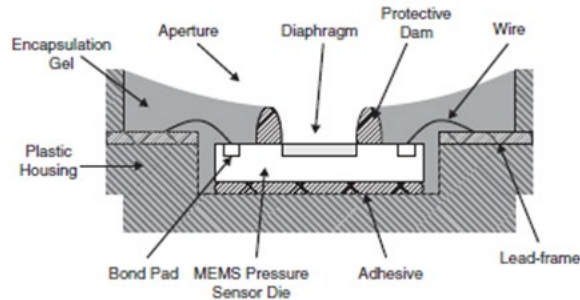


Figure 8.13 Plastic-encapsulated MEMS pressure sensor device from Motorola [22].

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 (“Hicks,” Ex-1025) teaches that the coating could be an epoxy or an ink. For example, Hicks states that “the flexible sensor may contain a light blocking layer applied to the top surface of the clear flexible substrate to minimize the effect of ambient light sources upon the sensor,” which “may include a separate substrate interconnected to the clear flexible substrate or some sort of opaque coating applied to the top surface of the clear flexible substrate.” Ex-1025, 2:42-48 (Hicks). Hicks further teaches that “traces 70-76 of the present embodiment are formed on the top surface of the clear substrate 80 using

a conductive ink (e.g., epoxy with silver).” Ex-1025, 10:15-17 (Hicks). Moreover, Hicks teaches that “[d]uring the ink deposition process, the remainder of the surface of the clear substrate 80 not covered by the conductive traces 70-76 (and not to be covered by the LED 40, 42 or Photodetector 38) may also be covered by an opaque nonconductive ink.” Ex-1025, 10:20-27 (Hicks). “That is, the non-patient side of the clear substrate 80 may be ‘painted’ to provide a light blocking shield for the sensor 30.” Ex-1025, 10:20-27 (Hicks); *see also* Ex-1025, 9:6-15 (Hicks) (“The release liner 84, the interconnecting layer 82, the foam layer 86 and the clear substrate layer 80 are formed of materials that are substantially transparent to ultraviolet (UV) light. This allows UV light to pass through these layers 80-86 such that any adhesives used to attach the LEDs 40, 42 and photodetector 38 to the electrical traces 70-76 and/or to the clear substrate 80 (i.e., adhesive drop 110) may be cured with light (i.e., UV or visible depending on the adhesives) applied through the bottom of the flexible substrate 50 at or near the end of the manufacturing process.”), 12:2-13 (“[T]his embodiment further uses a cover layer 94 covering the top surface of the clear substrate. ... The cover layer 94 covers substantially the entire top surface of the clear substrate 80, excluding the portion of the clear substrate that makes up the integral connector 94. This cover film layer 94 is generally an opaque flexile layer made up of a material similar to the clear substrate 80 and is utilized for its light blocking characteristics.”).

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.*, Ex-1006, 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 [sic], 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.

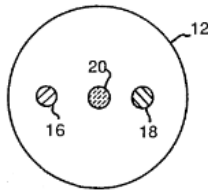


FIG. 2a

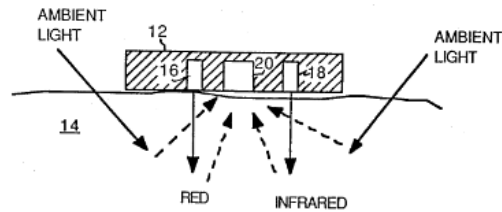


FIG. 2b

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.

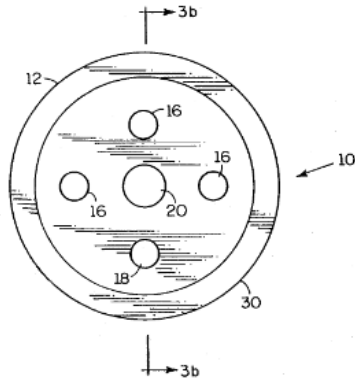


FIG. 3a

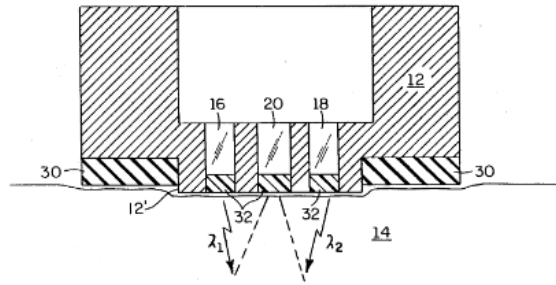


FIG. 3b

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 wavelengths 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.

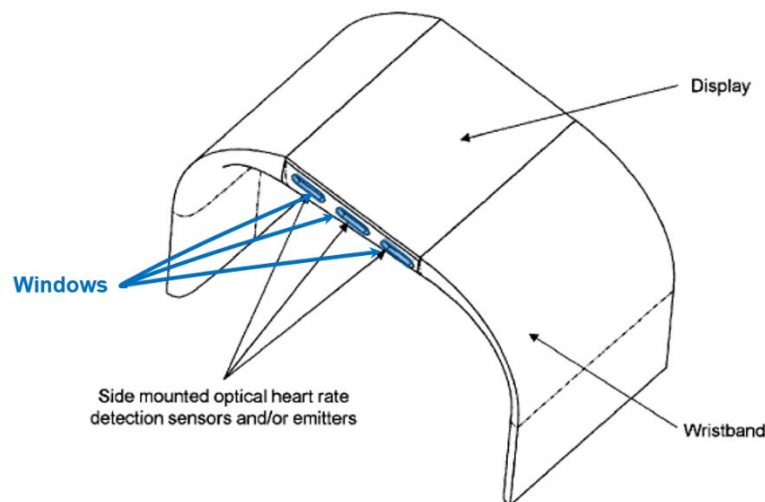


FIG. 12

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-10T45 ¶295. In the finger pulse oximeter, Tran’s device “emits lights from a window in the infrared spectrum and

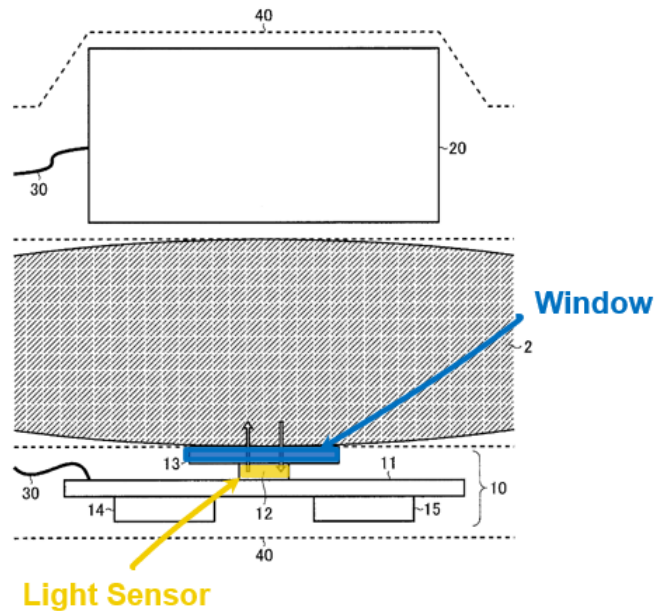
receives reflected light in a second window. When the heart beats, blood flow increases temporarily and more red blood cells flow through the windows, which increases the light reflected back to the detector. The light can be reflected, refracted, scattered, and absorbed by one or more detectors. Suitable 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, Nyiradi 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 the plastic arm strap 11 itself to penetrate the material of the plastic arm strap 11.” Ex-1047, 0012 (numbered page 11).

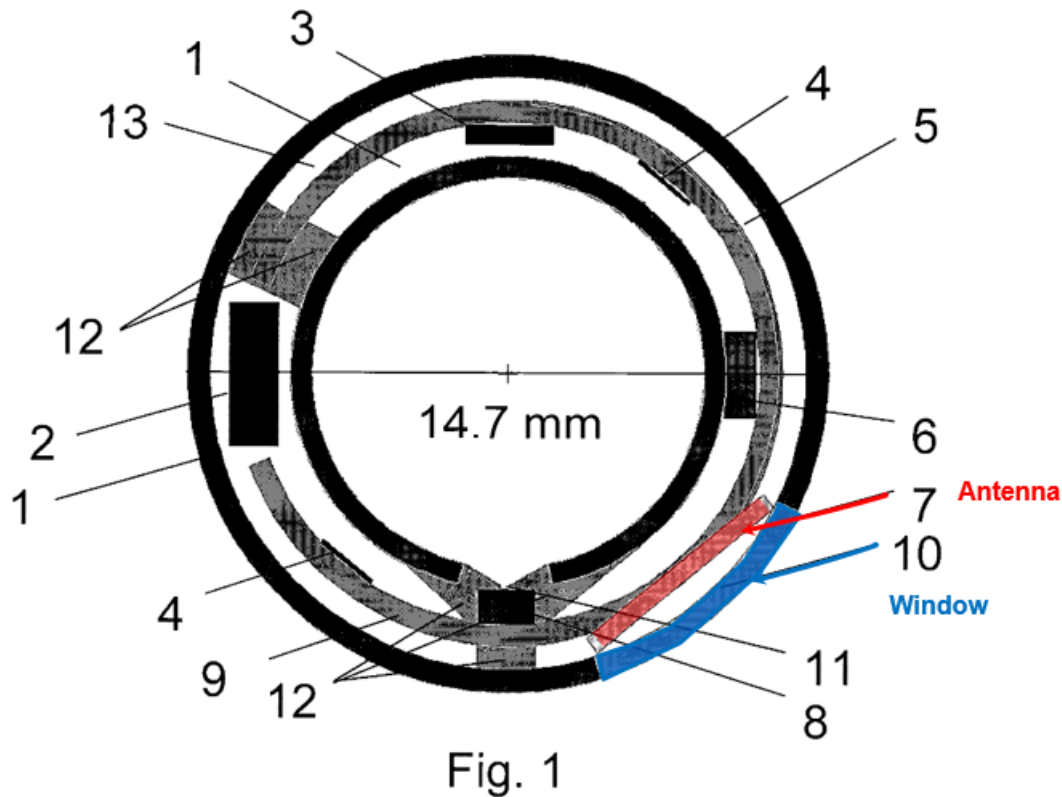
119. Therefore, windows and transparent materials for optical transmission were well-known in order to focus the light from a light-emitting component, such as a light emitting diode, to be emitted through and reflected back to the light receiving component, such as a photodetector.

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 of Sensors and Other Electronic Components 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.

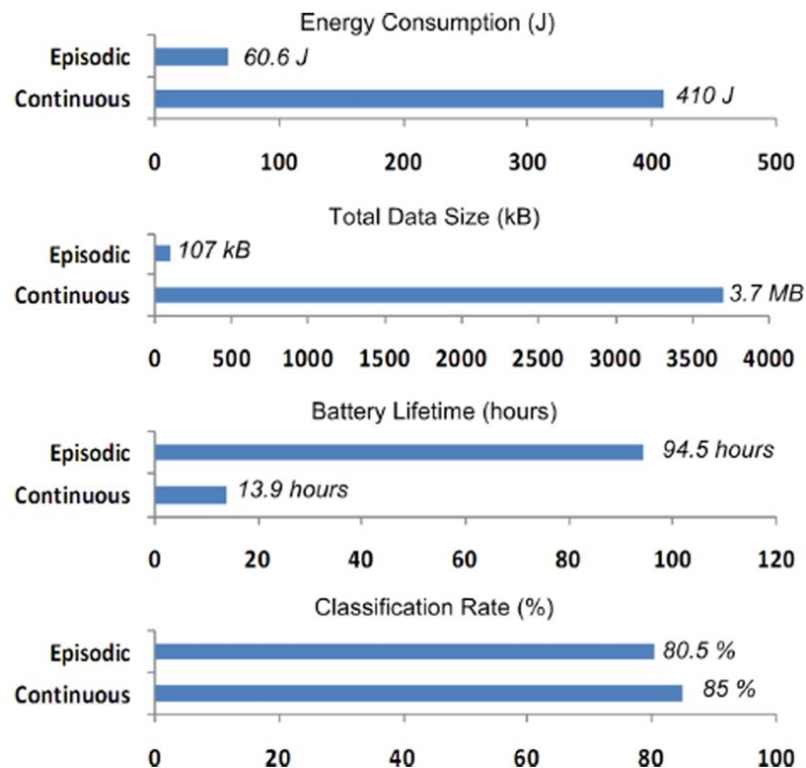


Fig. 5.
Experimental Results - Continuous vs. Episodic Sampling

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. By doing so, it optimizes the sensor’s operational efficiency and extends the device's battery life. For instance, during periods of low activity or when

the sensor detects minimal changes in the monitored parameters, the measurement frequency can be decreased, conserving energy. Conversely, during periods of high activity or when significant changes are detected, the measurement frequency can be increased to ensure accurate monitoring. This dynamic adjustment not only enhances the device's longevity but also ensures that it provides reliable and relevant data, tailored to the user's needs and the sensor's operational context.

129. Also well-known by 2013 was the need to minimize power consumption of other electronic components, in particular components with high power requirements such as transceivers. As a publication by Chen noted in 2009, in a wearable sensor system “[m]ost power is consumed by the wireless transceiver.” Ex-1067, 3 (Chen 2). As shown in Table 1 from Chen 2, reproduced below, transceivers typically have orders of magnitude higher power requirements than, for examples, microcontrollers or accelerometer.

Table 1- Power, size, and weight analysis for the wearable sensor unit

Component	Typical current (mA)	Size (mm)	Weight (oz)
MMA7260Q accelerometer	0.5	6×6×1.45	0.05
C8051F353 microcontroller	5.8	9×9×1.6	0.05
XBee 802.15.4 transmitter	45	25×28×2.8	0.14
Li-Ion 18650 battery pack	-	69×54×18	9.0

130. Therefore, A POSITA knew at the time that minimizing power consumption in transceivers was crucial for enhancing battery life, reducing heat generation, and improving overall system efficiency, especially in wearable electronic devices. Wearables, such as fitness trackers, smartwatches, smart rings, and health monitoring devices, rely heavily on efficient power management to ensure long battery life while maintaining functionality. One fundamental approach to efficient power management is efficient circuit design, which includes selecting low-power components and integrating sleep or standby modes. Sleep modes are particularly effective because they allow the transceiver to enter a low-power state during periods of inactivity, significantly reducing power usage when the device doesn't need to transmit or receive data.

131. Dynamic Voltage and Frequency Scaling (DVFS) also plays a pivotal role by adjusting the voltage and frequency according to transceiver workload, a rest mode between fully awake and sleep, ensuring efficient operation even when the device is active. Power management techniques like power gating and clock gating are essential, as they turn off power or disable the transceiver clock signal to idle parts of the circuit, maximizing power savings when combined with sleep modes. Energy-efficient modulation schemes, such as binary phase-shift keying (BPSK) or quadrature amplitude modulation (QAM), further reduce power consumption, especially when paired with sleep modes to conserve energy whenever possible.

132. Efficient antenna design and beamforming techniques maximize signal transmission and reception efficiency, reducing power needs and allowing the transceiver to remain active only when necessary. Power-efficient protocols and data reduction techniques minimize the amount of data transmitted or received, further optimizing power consumption. Hardware and software co-design, which involves co-optimizing algorithms and components, results in lower power consumption. Intelligent software management of transitions between active and sleep states enhances the effectiveness of these strategies.

133. A combination of these strategies, particularly the effective use of sleep modes, can significantly reduce power consumption for transceivers in wearable electronic devices. This leads to longer battery life and improved user experience, tailored to the specific requirements and constraints of the application, such as performance, cost, and form factor.

134. As an example, Mestas teaches that its athletic monitoring wristband had a sleep mode and can “exit[] the sleep mode...upon an activity sensor detecting movement or activity.” Ex-1010 ¶231. U.S. Patent No. 9,218,058 to Bress et al. (“Bress”) teaches a finger-ring based gesture recognition device with a low-power or “sleep” mode, further explaining that “[e]nergy management is critical in wireless devices.” Ex-1016, 15:61-64. Bress further teaches that in the “sleep” mode, “many of the subsystems may be shut down,” including “[a]ny and all of the

communications channels, such as BlueTooth...and WiFi.” *Id.*, 16:3-7 (Bress). The processor polls the sensors, including motion sensors and “[s]ensor data during the brief awake times would determine if there is any need to stay awake to verify a change of state, resume sleep, or fully wake up.” *Id.*, 16:8-14 (Bress). U.S. Patent Publication No. 2011/0080339 to Sun et al. (“Sun”) teaches a finger mouse with a “a suspension mode, sometimes referred to as ‘go to sleep,’” which could be activated by particular gestures. Ex-1015 ¶37 (Sun); *see also id.* ¶42 (disclosing a predefined gesture, “Single tap on top side 80,” as corresponding to the “Go to sleep” command).

E. Gesture Recognition Sensors and Techniques Were Known

135. Gesture recognition technology provides an interface between humans and machines, enabling intuitive and natural interaction without the need for traditional input devices such as keyboards or mice. This technology, which was well known to a POSITA by 2013, leverages sensors embedded in wearable or handheld devices, or non-contact ambient sensors, to interpret human gestures, facilitating applications across various domains such as gaming, healthcare, and automation.

2. Hardware for gesture recognition was well-known

136. Gesture recognition technology is embedded in various devices designed for both everyday use and specialized applications. Such devices were in

existence and well known to a POSITA by 2013. These devices leverage the combined capabilities of accelerometers, gyroscopes, magnetometers, cameras, and retroreflectors to provide accurate and responsive gesture-based interactions. Software algorithms, also well-known by 2013, process and interpret gesture data, determining whether it matches pre-defined gesture patterns.

137. Accelerometers: Accelerometers are sensors that measure acceleration forces along three axes (x, y, and z). These forces can arise from gravity or movement, providing important data about the device's orientation and motion. In gesture recognition, accelerometers are used to detect linear movements and tilts. Their small size, low power consumption, and affordability make them ideal for integration into wearable devices such as smart rings and watches, as well as handheld controllers.

138. From a technical perspective, accelerometers function based on the principle of piezoelectricity or changes in capacitance, which are converted into electrical signals proportional to the acceleration. They capture detailed information about the speed and direction of movements, enabling differentiation between various types of gestures. For example, a rapid flick of the wrist can be distinguished from a gentle wave based on the acceleration profile captured by the sensor. This capability is essential for applications requiring precise gesture recognition, such as in fitness tracking and gaming.

139. Accelerometers and their use in wearable electronic devices were well-known by 2013. For example, U.S. Patent Publication No. 20140244009 to Mestas teaches a wearable athletic monitoring device having various sensors, including an accelerometer for detecting the user's motion. Ex-1010 ¶¶201 (Mestas). U.S. Patent Publication No. 2010/0219989 to Asami et al. ("Asami") teaches a finger ring including a current sensor and a triaxial acceleration sensor for recognizing characters and figures drawn by the user. Ex-1014, Abstract. U.S. Patent Publication No. 2011/0080339 to Sun et al. ("Sun") teaches a wrist/finger mouse that detects the motion of the user's wrist or finger using an acceleration sensor. Ex-1015 ¶¶24, 36 (Sun). U.S. Patent No. 8,031,172 to Kruse et al. ("Kruse") teaches a haptic ring that identifies gestured performed by the user wearing it based on motion sensed by an accelerometer. Ex-1017, 3:34-39 (Kruse). U.S. Patent No. 9,218,058 to Bress et al. ("Bress") describes a wearable input device, referred to a "Imagine," with motion sensors, including accelerometers, in rings worn by the user on their finger. Ex-1016, Abstract, 6:13-16, Fig. 4 (Bress). A 2010 study described that "the technology of sensors is advancing significantly, allowing for very small, body-worn, wearable sensors...suitable for intuitive wearable computing systems. Traditionally used sensors, which are small and come at very reasonable costs are accelerometers, gyroscopes and magnetometers." Ex-1068, 1 ("Amma"). Amma notes that the accelerometers used in their wearable input device are "3-axis

accelerometers [] available as standard flat integrated c[i]rcuits.” *Id.*, 2 (Amm). Another publication describes a “ring shape,” “micro wearable device based on a tri-axis accelerometer” that is “put [] on a finger to detect the finger gestures.” Ex-1069, Abstract, Fig. 1 (“Zhou”). The Zhou device used an off-the-shelf tri-axis accelerometer, MMM7361L from Freescale Semiconductor, Inc. *Id.*, 2.

140. Gyroscopes: Gyroscopes measure the rate of rotation around three perpendicular axes, offering detailed information about the device’s angular velocity. When used in conjunction with accelerometers, gyroscopes enhance the accuracy of motion tracking by providing complementary rotational data. This synergy is particularly beneficial in dynamic environments where precise gesture recognition is required, such as in gaming controllers and virtual reality systems.

141. Gyroscopes function based on the Coriolis effect in MEMS (Micro-Electro-Mechanical Systems) devices, where vibrating structures are used to detect changes in orientation. Gyroscopes enable the system to track the orientation. The ability to measure rotational velocity also aids in distinguishing between different types of gestures, such as a twist versus a spin, by analyzing the rate and axis of rotation.

142. Gyroscopes and their use in wearable electronic devices were well-known by 2013, and gyroscopes were often used in conjunction with accelerometers for additional versatility in detecting various motions, in particular for gesture

recognition. For example, Mestas teaches that in its athletic monitoring device “[p]hysical gestures and movements may be detected using an accelerometer, a gyroscope and/or other sensors.” Ex-1010 ¶221 (Mestas). Sun teaches that “representative MEMS [microelectromechanical systems]” sensors for its gesture-based wrist/finger mouse include, besides accelerometers, “gyroscopes, including capacitive or piezoelectric vibrating gyroscopes.” Ex-1015 ¶25 (Sun). Bress’s gesture-recognition input device similarly teaches that its finger-ring motion sensors include gyroscopes. Ex-1016, Fig. 4 (Bress). The publication by Amma in 2010 also teaches the use of “gyroscopes for measuring angular velocity” in wearable input devices. Ex-1068, 2 (Amma). Similarly, Park noted in 2011 that “[r]ecently, hand-worn accelerometer and gyroscope sensor-based gesture recognition has been successfully used in mobile and pervasive computing. This approach is appealing because it is low cost, low power, requires only lightweight processing, and can be implemented with compact form factors. Several projects have proposed gesture recognition systems based on a wide range of sensing form factors.” Ex-1070, 262 (Park). Park further explains that “while the accelerometer is often used in gesture recognition systems...recent research demonstrates that additional use of a gyroscope can improve gesture classification accuracy...by up to 4% because it can detect rotational movements.” *Id.*, 263.

143. Magnetometers: Magnetometers detect magnetic fields, allowing

devices to determine their orientation relative to the Earth's magnetic field. This capability is useful for maintaining accurate spatial orientation over time, especially when combined with accelerometer and gyroscope data in sensor fusion algorithms. Magnetometers are commonly found in devices and controllers, where they contribute to reliable and accurate gesture-based interactions.

144. From a practical standpoint, magnetometers function using the Hall effect or magnetoresistive effects, converting magnetic field strength into an electrical signal. They play an important role in correcting drift errors in gyroscopes by providing an absolute reference point based on the Earth's magnetic field. This is particularly important in applications such as navigation and applications, where precise spatial awareness is critical. The use of magnetometers for motion sensing and gesture recognition was well-known by 2013. For example, Amma described that by 2010 "the technology of sensors is advancing significantly, allowing for very small, body-worn, wearable sensors...suitable for intuitive wearable computing systems. Traditionally used sensors, which are small and come at very reasonable costs are accelerometers, gyroscopes and magnetometers." Ex-1068 at 1 (Amma).

145. Other hardware for gesture recognition: There were other devices for gesture recognition known to a POSITA by 2013, including cameras and retroreflectors. Cameras in gesture recognition systems offer high-resolution visual data that can be processed to interpret complex gestures. By capturing images or

video frames of the user's movements, cameras enable a non-invasive method of gesture tracking that does not require physical contact with the device. Retroreflectors are materials that reflect light back to its source with minimal scattering, enabling precise tracking of objects equipped with these reflectors. When combined with cameras or infrared sensors, retroreflectors can enhance the accuracy of gesture recognition systems by providing distinct and easily detectable markers on the user's body or accessories. In practical terms, retroreflective markers can be placed on gloves, rings, or wristbands, allowing cameras or infrared sensors to track the precise position and movement of the hands and fingers. Examples of such devices are described, for example, by Rekimoto, who describes several gesture recognition systems, including a "camera-based gesture recognition system that can be worn like a pendant." Ex-1071, 22 (Rekimoto).

3. Gesture recognition techniques were well-known

146. The interpretation of sensor data into recognizable gestures relies on algorithms that process and analyze the raw data collected by hardware sensors. Virtually all gesture recognition performed by an electronic device employs such algorithms. These algorithms transform motion and orientation data into meaningful gestures that are compared for recognition against a predetermined patterns and acted upon by the system based on the outcome of that comparison. Such algorithms were well-known by 2013. For example, Park noted in 2011 that "[m]any gesture

classification algorithms have been proposed to classify a segmented gesture into one of many predefined gestures or as garbage, e.g., HMM, Template matching...Dynamic Time Wrapping (DTW)...and light-weight HMM.” Ex-1070, 262 (Park).

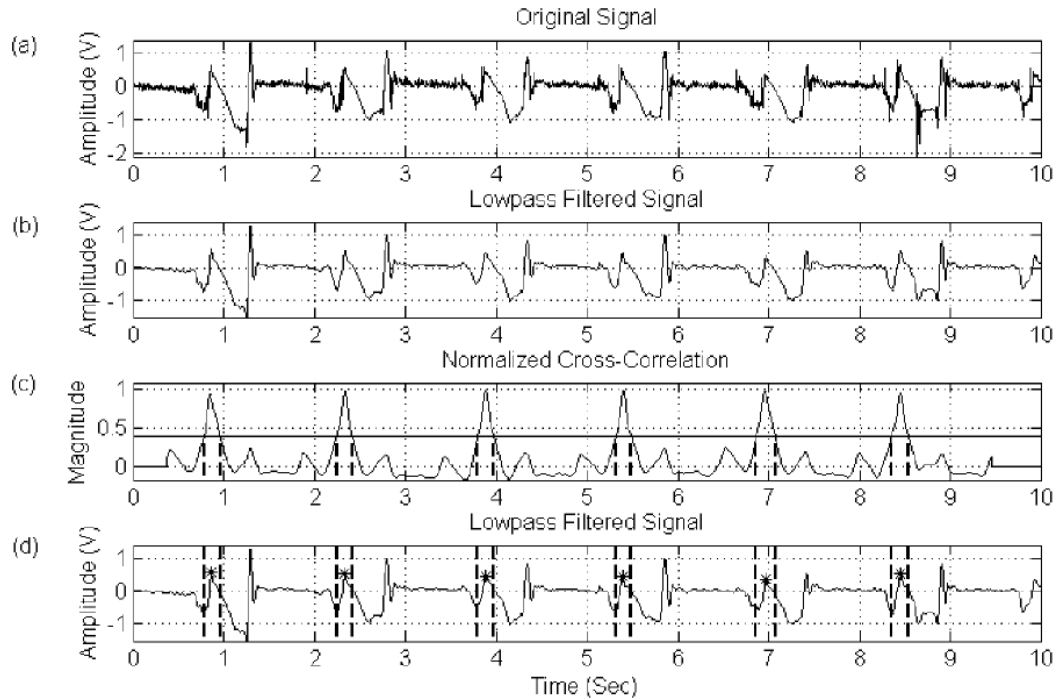
147. Template Matching: This approach compares input gestures, defined as time series signals, to pre-defined templates stored in the system by calculating the correlation between the two and is among the simplest gesture recognition algorithms. This technique is particularly effective for detecting specific gestures from sequences of sensor data, such as those captured by accelerometers, gyroscopes, and other sensors. The primary objective is to detect/locate the point in the time series where the gesture template best matches the observed signal. When a user performs a gesture, the template matching algorithm calculates the similarity between the input data and the templates to determine the best match, usually by calculating coefficients of correlation between the detected motion and the stored template.

148. Cross-correlation is a method that measures the similarity between two time series as a function of the time-lag applied to one of them. The core of cross-correlation involves computing the cross-correlation function for each possible time lag. Normalized cross-correlation, on the other hand, extends the principles of cross-correlation by accounting for differences in signal amplitude and energy, thus

providing a more robust measure of similarity. This normalization is used for comparing signals of significantly varying magnitudes.

149. Template matching using cross-correlation and normalized cross-correlation is straightforward and efficient, making it suitable for applications with a limited set of predefined gestures. The simplicity of these methods makes them easy to implement and interpret. Normalized cross-correlation, in particular, provides robustness to variations in signal amplitude and energy, making it effective in real-world applications. These methods can be efficiently computed, even for large datasets, using fast Fourier transform (FFT) techniques. However, their simplicity can also be a limitation in scenarios requiring recognition of a wide variety of gestures.

150. As an example of template matching using cross-correlation, Ying described an automatic step detection using an accelerometer signal. Ex-1072 (Ying). Ying describes that “[t]he main concept of the template-matching method is to generate a template, which represents a typical step cycle. In the unknown signal, an event is declared to be detected when there is a match between the signal and the template to certain degree.” *Id.*, 82 (Ying). Ying describes that “the normalized cross-correlation...is calculated between the template and signal,” and the peak values in the calculated normalized cross-correlation, shown in Figure 6 of Ying, reproduced below, represent the pattern detected in the signal.



151. As an example of template matching for gesture recognition, Sun describes the use of “comparator logic” for use in “comparing input sequences of data indicating gestures ... with stored sequences of data specifying the unique signatures for memorized gestures.” Ex-1015 ¶43 (Sun).

152. Statistical Methods - Hidden Markov Models (HMMs): HMMs represent gestures as sequences of observable events, capturing the probabilistic nature of human motion. Each gesture is modeled as a series of states with transition probabilities, allowing the algorithm to handle variations in gesture execution. HMMs are particularly effective in recognizing gestures with temporal dependencies, such as sequential hand movements. An example of HMMs is described in Park (Ex-1070). Park explains that the principles of HMM-based

gesture recognition: “For each gesture, an HMM model is built and trained based on a set of collected gesture samples....We also build a garbage HMM model to filter out non-gestural movements or undefined gestures that frequently occur, e.g., ‘raising a hand to eat food’. ...At runtime, a potential gesture segmented by the sensor device is classified as one of the defined gestures or garbage. We calculate a Feature Vector (FV) series containing 18 elements, i.e., raw data, delta data, and integral data for each axis of the 3D accelerometer and the 3D gyroscope from the segmented samples. From the FV series, we use the Viterbi algorithm...to efficiently calculate the likelihood of each gesture model. Then, the gesture model M with the highest likelihood is selected as the classified gesture.” Ex-1070, 266 (Park).

153. Machine Learning: One machine learning technique, Support Vector Machines (SVMs), classifies gestures based on feature vectors derived from sensor data. The algorithm learns to separate different gesture classes by finding the optimal hyperplane that maximizes the margin between classes. SVMs are known for their robustness and accuracy, making them suitable for gesture recognition tasks with well-defined feature sets.

154. Another machine learning technique is Neural Networks (NNs). Deep learning models, such as Convolutional Neural Networks (CNNs), are capable of learning complex patterns in gesture data, offering high accuracy and adaptability. NNs can automatically extract relevant features from raw sensor data, making them

well-suited for recognizing a wide range of gestures. The flexibility of NNs allows them to adapt to new gestures and variations in execution, providing a scalable solution for gesture recognition. An approach combining a neural network with an HMM algorithm is described in Zhu's Smart Assisted Living (SAIL) system, designed to perform hand gesture recognition. Ex-1073 (Zhu). Zhu's algorithm is shown in Figure 2, reproduced below. *Id.*, Fig. 2 (Zhu).

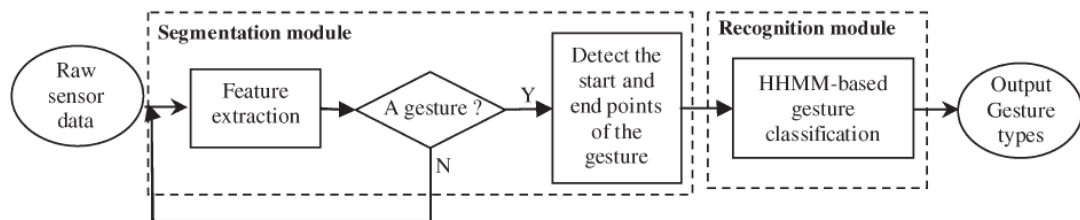


Fig. 2. Flowchart of the hand gesture recognition algorithm.

155. Dynamic Time Warping (DTW) and Dynamic Time and Space Warping (DTSW): DTW measures the similarity between two temporal sequences, accommodating variations in speed and timing. This algorithm aligns the sequences by stretching or compressing them to achieve the best match. DTW is effective for recognizing gestures with temporal variations, such as those performed at different speeds. DTSW extends the principles of DTW by not only aligning temporal sequences but also considering spatial variations in the data. This makes DTSW particularly suitable for gesture recognition tasks where both the timing and spatial configuration of the gesture are important. Examples of these techniques are described, for example, in Liu, which describes in 2009 the use of Dynamic Time

Warping in uWave, an accelerometer-based personalized gesture recognition system. Ex-1074 (Liu). Figure 1 of Liu, reproduced below, illustrates the recognition process in Liu's system.

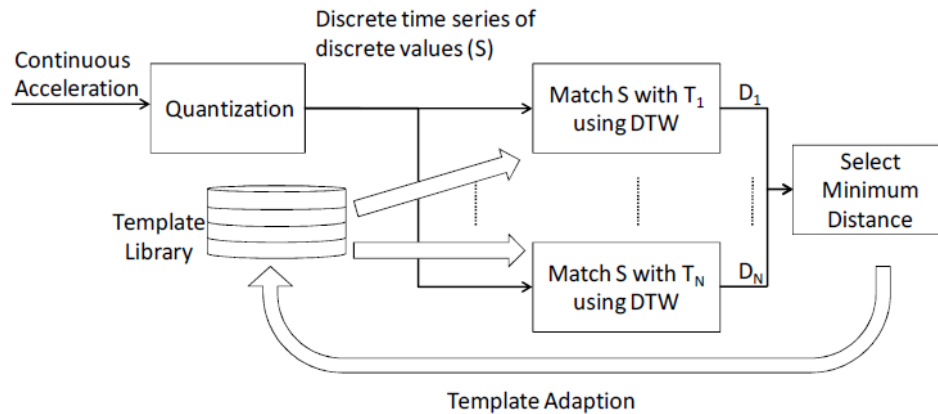


Figure 1: uWave is based on acceleration quantization, template matching with DTW, and template adaptation

156. Liu explains this recognition process as follows: “The input to uWave is a time series of acceleration provided by a three-axis accelerometer. Each time sample is a vector of three elements, corresponding to the acceleration along the three axes. uWave first quantizes acceleration data into a time series of discrete values. The same quantization applies to the templates too. It then employs DTW to match the input time series against the templates of the gesture vocabulary. It recognizes the gesture as the template that provides the best matching.” Ex-1074, 3 (Liu).

4. Multiple instances and training mode

157. In a gesture recognition system, the primary reason for using multiple examples—or instances—of gestures is to capture the inherent variability in how the

same or different individuals perform the same gesture. This variability is crucial because gestures differ based on factors such as hand size, motion speed, angle, and the personal style and personal variation of the individual. For instance, a hand wave gesture might be performed with different speeds, amplitudes, and trajectories by different people or by the same person at different times. By training the model on a diverse set of gesture examples, it learns to generalize better, enabling it to accurately recognize gestures performed by various individuals. During training, each gesture example is used to update the model's parameters—such as weights and biases in a neural network—through techniques like gradient descent. The model adjusts these parameters iteratively to minimize the error, which is the difference between the predicted gesture class and the actual gesture class, across all training examples. This iterative process helps the model become more robust and capable of recognizing gestures in a wide range of conditions. Training a gesture recognition system by using multiple instances of a gesture was well-known by 2013. For example, Sun teaches a training mode for its wrist/finger mouse, that permits assigning new command gestures for controlling an external computer. Ex-1015 ¶33 (Sun). In Sun's training mode, the user specifies a new input command, to which a new gesture should be mapped. *Id.* The user then performs the new gesture multiple times, resulting in the generation of “a composite new command gesture,” which is “added to the library of command gestures” stored on

the wrist/finger mouse. *Id.* Further, in a 2008 publication, Schlömer described the training of an accelerometer-based Wii-controller to recognize “arbitrary gestures by users which can then be recalled for interacting with systems like photo browsing on a home TV.” Ex-1075, 11 (Schlömer). Schlömer explains that “[t]he system was trained using the leave-one-out method to make sure that the models were evaluated on sequences that were not used for training....for each participant fifteen training sets each containing the five gestures were computed.” *Id.*, 14 (Schlömer).

158. In the context of gesture recognition, learning involves understanding the mean (average) and the variance (spread) of the gesture data. A fundamental concept in statistics, “[t]he most familiar property of a distribution is its mean, or expected value.” Ex-1076, 33 (Murphy). The mean gesture represents the typical or average way a gesture is performed. For example, the average motion path of a hand wave gesture might be a smooth arc moving from left to right. Another fundamental statistical concept, “[t]he variance is a measure of the ‘spread’ of the distribution.” *Id.* In gesture recognition, the variance measures how much individual gesture performances deviate from the average path, indicating the degree of variability. High variance means that the gesture performances are widely spread out from the mean, reflecting diverse ways of performing the gesture, while low variance means they are closely clustered around the mean, indicating more uniform performances. For instance, the variance in the speed and angle of a hand wave

gesture might be higher if the dataset includes gestures from people with different hand sizes and motion styles. Understanding both these metrics allows the model to grasp what a typical gesture looks like and how much variation to expect, ensuring that it can accurately recognize the gesture even when performed differently by different users.

159. Knowing the mean and variance of gestures is crucial for setting bounds or thresholds—also known as error tolerances—during training. These bounds help define what is considered a normal or typical gesture performance. For instance, in a gesture recognition system, confidence intervals (e.g., mean $\pm$ 2 standard deviations) can be established to determine the range of normal gesture variations. Gestures that fall outside these intervals might be considered outliers or misclassified gestures. For example, if the typical hand wave gesture involves a horizontal movement of the hand at a certain speed and amplitude, any gesture significantly deviating from this range might be flagged as incorrect or needing further review. Setting a maximum allowable variation, or error tolerance, permits detection of a gesture motion that is performed within the expected range. This approach helps the system to filter out false positives and negatives, improving the overall accuracy and reliability of the gesture recognition. Moreover, setting these bounds allows the system to handle edge cases where gestures are performed under unusual conditions, such as by users with unique physical characteristics.

160. During the training phase of a gesture recognition model, the model learns to map inputs (gesture features) to outputs (gesture classes) using the mean and variance to establish patterns within the gesture data. For example, the model might learn that a hand wave typically involves a horizontal movement of the hand at a certain speed and amplitude, following a specific trajectory. In the inference phase, when the model is applied to new gesture data, it uses the learned parameters to make predictions. It compares new gesture inputs against the learned patterns to determine if they fall within the expected range of a recognized gesture. This comparison helps identify whether a new gesture is typical (nominal) or an anomaly. For instance, a new hand wave gesture will be checked against the typical features of hand waves learned during training to confirm it is indeed a hand wave. If the new gesture falls within the established bounds, it is classified as a recognized gesture; otherwise, it might be flagged for further analysis.

161. The process of learning the mean and variance from multiple gesture examples is a fundamental aspect of training gesture recognition models and was well-known to a POSITA in 2013. For example, in a 2012 publication, Trigueiros described a comparison of machine learning algorithms applied to camera-based hand gesture recognition, where the mean and variance were used as parameters for the training datasets. Ex-1077, 2 (Trigueiros).

162. In supervised learning, models are trained on labeled gesture data,

learning the mean and variance for each gesture class, which aids in accurately recognizing different gestures. For instance, the model might learn the typical motion paths, speeds, and angles for gestures like swiping, pinching, or waving. In unsupervised learning, models find patterns in gesture data without explicit labels, and techniques like clustering (e.g., K-means) rely on the mean and variance to group similar gestures together. Even in reinforcement learning, where agents learn optimal actions through trial and error, the mean and variance of rewards guide the learning process. These principles are supported by the Central Limit Theorem, which states that the distribution of sample means approaches a normal distribution as the sample size grows, and the Law of Large Numbers, which states that the sample mean converges to the true mean as the number of trials increases. Both underscore the importance of using multiple gesture examples, or instances, to accurately learn these statistical properties, ensuring the model is robust and reliable. As a practical example applying these principles, a gesture recognition model can be designed to identify hand gestures for controlling a smart device, such as a television or a home automation system. The model learns the mean and variance of each gesture to make accurate recognitions. For instance, the model might learn that the mean path of a “swipe left” gesture involves a horizontal movement from right to left across the device screen, with a typical speed and distance. Training the model on a large, diverse dataset of “swipe left” gestures helps it generalize better to new,

unseen gestures. This dataset might include swipes performed by different individuals, under varying lighting conditions, and with different hand positions. By understanding the typical characteristics and the expected range of variations in the “swipe left” gesture, the model can make informed recognitions and identify gestures that are unusually slow, fast, or deviate significantly from the average path, thus flagging potential misclassifications for further review. This ensures that the system remains accurate and reliable in real-world applications, providing a seamless user experience. Use of gesture recognition to control, for example, televisions or smart home devices was well-known by 2013. As an example, the Sun patent publication describes a “wrist/finger mouse” that employs gesture recognition using motion sensors and that could be also used as a “television remote control” or “a control for digital home devices.” Ex-1015 ¶48 (Sun). Rekimoto also discusses a “hand-gesture input system that is used as a remote control method,” in which “[a] wearer can control a presentation system by using hand-gestures.” Ex-1071, 22 (Rekimoto).

VI. THE PRIOR ART IN THE APPLIED INVALIDITY GROUNDS

A. Sun (Ex-1015)

163. Sun (U.S. Pat. Pub. No. 2011/0080339) was filed October 7, 2009, and published April 7, 2011. As explained to me by counsel, I understand that Sun qualifies as prior art to the ’953 patent.

164. Sun teaches a wrist/finger mouse and expressly teaches that the device can be configured for mounting on a finger, which a POSITA would understand to disclose that the device is in a finger ring form factor. Ex-1015, Fig. 2. This configuration offers several practical advantages, including ease of use, comfort, and convenience. By designing the device to be worn as a ring, it ensures that the user can maintain natural hand movements while seamlessly interacting with the device.

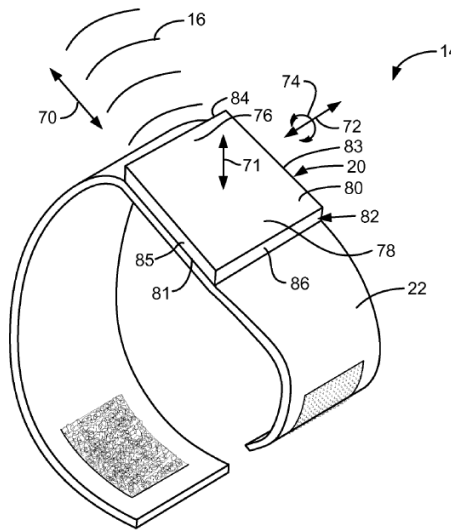


Fig. 2

165. Sun's device has motion sensors and other electronics inside. Ex-1015 ¶24. Sun's finger mouse detects the motion of the user's finger using an acceleration sensor (*id.* ¶¶24, 36) and compares it to predetermined gestures (*id.* ¶¶19, 44, Fig. 5). If there is a match, a respective command is transmitted by radio signal to an external computer (*id.* ¶¶19, 44). Sun's Figure 5, reproduced below, is a flow chart summarizing the operation sequence for Sun's finger mouse.

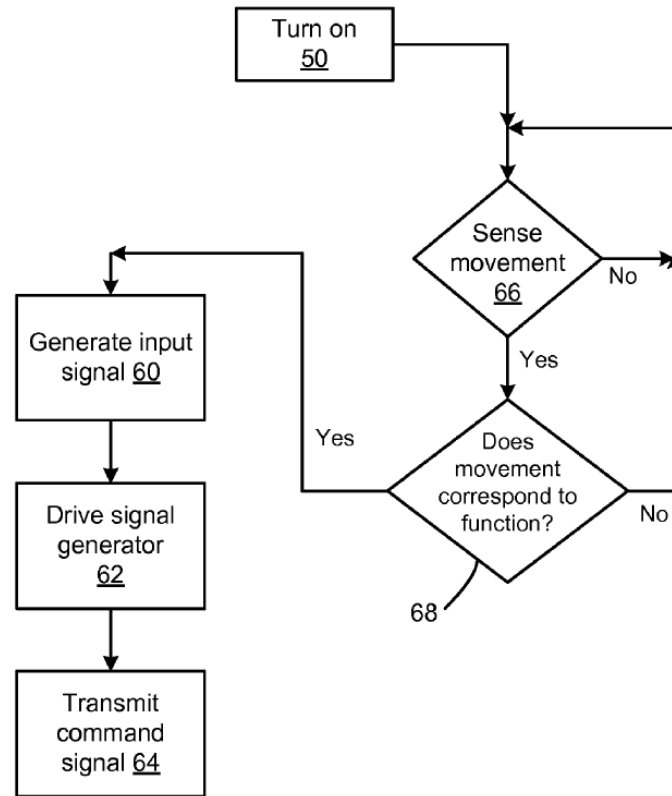
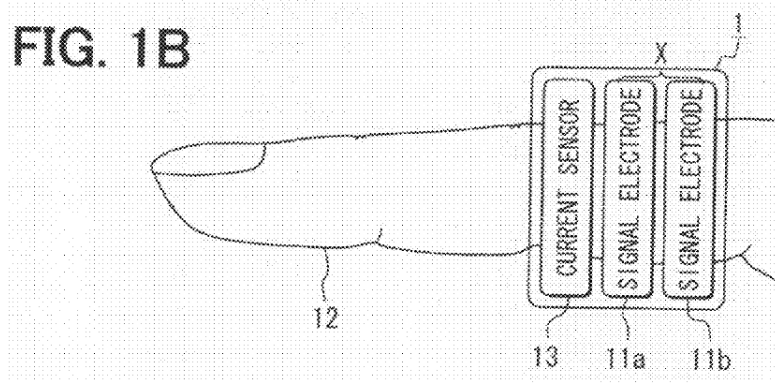


Fig. 5

B. Asami (U.S. Patent Publication No. 2010/0219989) (Ex-1014)

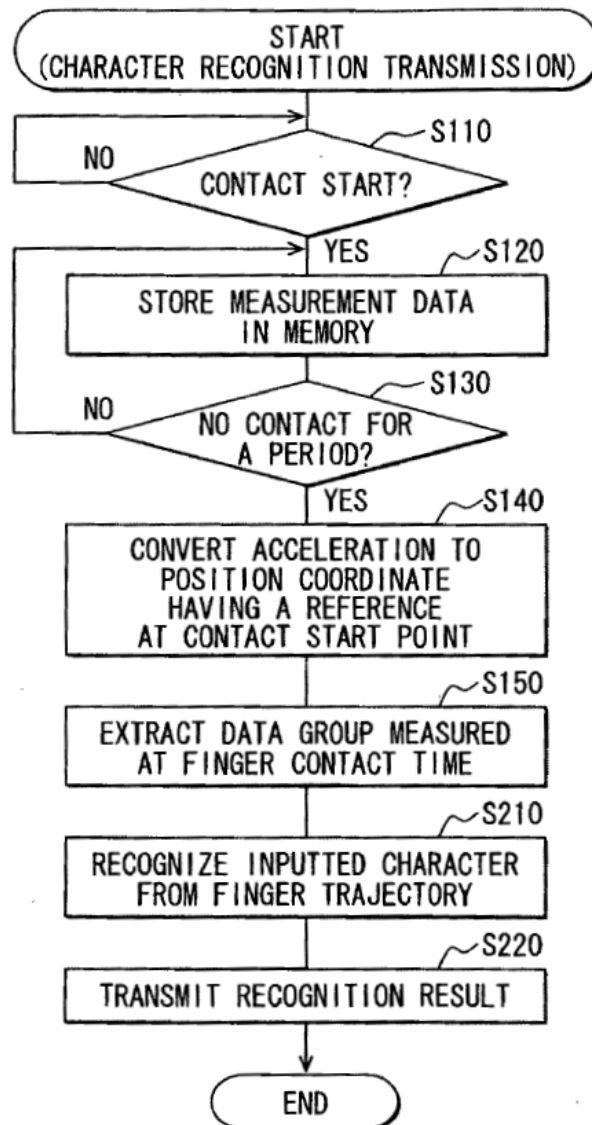
166. Asami was filed February 12, 2010, and published September 2, 2010. As explained to me by counsel, I understand that Asami qualifies as prior art to the '953 Patent.

167. Asami teaches a finger ring, depicted in Figure 1B, having motion sensors and other electronics inside. Ex-1014 ¶44, Fig. 1B.



168. Asami detects the motion of the user's finger using an acceleration sensor (*id.* ¶73), calculates the trajectory of the finger, and compares the trajectory to pre-stored character patterns (*id.* ¶96). If the character recognition results in a match, the result is sent using a radio transmitter to an external device. *Id.* ¶¶97, 99. Asami also determines other characteristics of the motion, for example detecting whether the user's finger was in contact or not with another body part during its motion. *Id.* ¶83; Figs. 8, 9A (flowcharts showing the sequence of character recognition operations in Asami's device).

FIG. 8



A. Bress (Ex-1016)

169. Bress (U.S. Pat. No. 9,218,058) was filed May 15, 2012 and issued December 22, 2015. As explained to me by counsel, I understand that Bress qualifies as prior art to the '953 Patent.

170. Bress teaches a “wearable input device, referred to as Imagine” that is

“able to recognize complex gestures.” Ex-1016, Abstract. Bress’s device “may include a plurality of motion sensors affixed to a user’s fingers.” *Id.* In one embodiment Bress’s “device’s finger sensors are in rings.” *Id.*, 6:13-16. Bress’s Imagine device has “onboard gesture recognition capability” (*id.*, 12:28-38) and can be used to transmit commands to a second electronic device, such as a computer. *See id.*, 9:11-13, 9:49-61, 13:43-45. The device has wireless communication capabilities through a Bluetooth or WiFi transceiver. *Id.*, 13:62-64, 16:3-7.

171. Bress teaches that “[e]nergy management is critical in wireless devices” and that its Imagine device has a low-power or “sleep” mode. Ex-1016, 15:61-64. In the “sleep” mode, “many of the subsystems may be shut down,” including “[a]ny and all of the communications channels, such as BlueTooth...and WiFi.” *Id.*, 16:3-7. The processor polls the sensors, including motion sensors and “[s]ensor data during the brief awake times would determine if there is any need to stay awake to verify a change of state, resume sleep, or fully wake up.” *Id.*, 16:8-14.

VII. CLAIM CONSTRUCTION

172. 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.

173. 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 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun

1. Independent Claims 16 and 30

- a. Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and**

174. To the extent the preamble is limiting, Sun teaches² Elements 16[pre(1)]/30[pre(1)].

175. Sun teaches a method adapted to a wearable computing device. *E.g.*, Ex-1015, Abstract. Sun further teaches flash memory “to store...application programs [and]...application logic...in support of the gesture interpretation...processes” and “ROM memory 41 for storing instructions,” which a POSITA would have understood constitute a non-transitory computer readable storage medium storing computer readable instructions for implementation by a

² Throughout this Declaration I use the term “teaches,” which I understand from counsel includes both express teachings and those fairly suggested to a POSITA.

processor of the device. *Id.* ¶43. As discussed in more detail below, Sun teaches a “microcontroller unit MCU 35,” which POSITA would have understood comprises a processor. *Id.* The MCU is integral to the device’s functionality, as it processes input from the sensors and executes the stored instructions to perform the desired tasks. The MCU 35 is responsible for managing the various components of the wearable device, including the motion sensors, memory interaction, and communication interfaces. By executing the application logic stored in memory the MCU can interpret gesture data, make decisions based on this data, and trigger appropriate responses, such as sending signals to external devices or providing feedback to the user.

176. Sun teaches that its wearable device is a wrist or “finger-mouse” that can be worn, e.g., on the user’s wrist or finger. Ex-1015 ¶17 (“Wrist/finger mouse 14 could also be configured for mounting to different parts of a user's hand, typically a finger.”); ¶40 (discussing “wrist/*finger mouse* 14 is attached on human wrist *or finger*.”); Fig. 2.

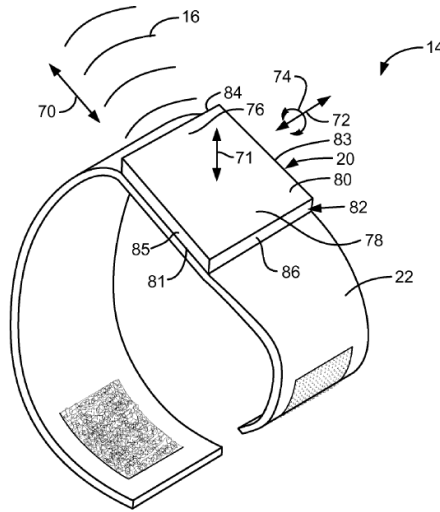


Fig. 2

177. A POSITA would have understood based on these disclosures that Sun's device is "in the form factor of a ring for being worn around the finger." A POSITA would have further understood that a user would have worn Sun's device on a finger as a ring, facilitating gesture control through its ergonomic design.

b. Element 16[pre(2)]: the wearable computing device comprising at least one sensor module having at least one sensor, at least one processor, and at least one transceiver; the method comprising / Element 30[pre(2)]: including a sensor module having a sensor and a transceiver, which instructions, when executed by the processor, causes the processor to perform operations comprising

178. Sun teaches Elements 16[pre(2)]/30[pre(2)], to the extent they are limiting.

179. Sun's device includes a sensor module, in the form of "[m]otion sensor 24," which "preferably includes very small microelectromechanical systems (MEMS) sensors." Ex-1015 ¶18, Fig. 3 (annotated below). As Sun further explains,

“a MEMS sensor” in its device can “include accelerometers, gyroscopes, etc.” which acquire “gesture data.” *Id.* ¶¶24, 26. Sun further explains that “[r]epresentative motion sensors 24 include inertial sensors and gyroscopes,” and a POSITA would have understood that this sensor or collection of sensors forms a sensor module³ in Sun’s device. Ex-1015 ¶21. A POSITA would have further understood that this sensor module is designed to capture detailed motion data, including linear acceleration and angular velocity, which are essential for accurately interpreting complex gestures.

180. Sun’s finger mouse also includes “motion sensitive circuitry 32,” which includes one or more processors. Ex-1015, Fig. 3. As Sun explains, circuitry 32 includes “data processing resources” (Ex-1015 ¶26), such as “*microcontroller unit MCU* 35,” for “*executing system firmware* and *coordinating processing* with application logic.” Ex-1015 ¶43, Fig. 3 (annotated below). A POSITA would have understood that the microcontroller unit (“MCU”) is a processor (of the one or more processors). Sun’s MCU plays a crucial role in the device's functionality by processing and executing the necessary computations and control tasks. It acts as the brain of the device, interpreting input from the motion sensors and performing the required processing to recognize gestures and execute corresponding commands.

³ Both Claim 16 and 30 recite that the sensor module could have a single sensor.

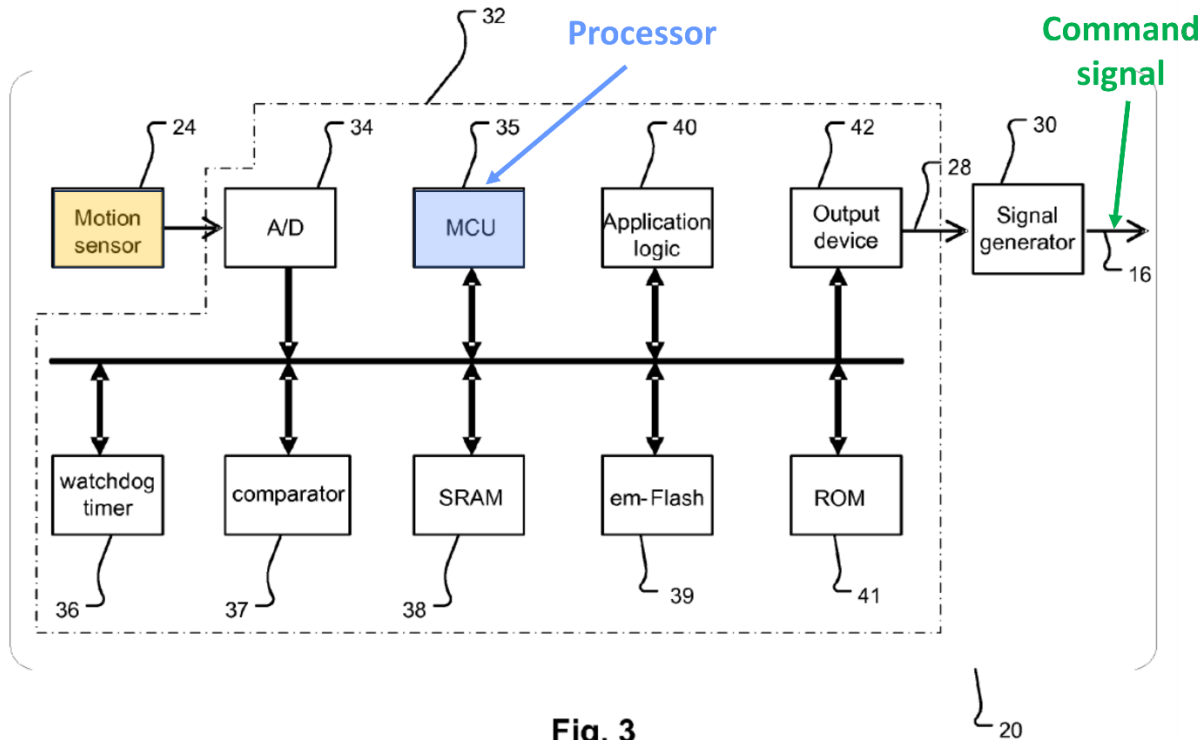


Fig. 3

181. As also shown in Figure 3, Sun's finger mouse also has a signal generator that produces a "command signal" that is transmitted to an external device, e.g., a computer. Ex-1015 ¶17. To perform this transmission Sun's finger mouse also includes "a communication port" (*id.* ¶24) and supports "communication protocols, such as *wi-fi*, *Bluetooth* or *Zigbee*, may be used." *Id.* ¶18. A POSITA would have understood that Sun's teachings correspond to and would require a transceiver in order to perform this communication, transceivers are critical components in wireless communication systems, as they handle both the transmission and reception of signals, and that in particular wi-fi, Bluetooth, and Zigbee are bi-directional wireless protocols that require transceivers to communicate.

182. As discussed at Elements 16[pre(1)]/30[pre(1)], Sun's device has transitory memory such as flash memory that contains instructions that are executed by a processor to perform operations. §VIII.A.1.a.

183. As I explained in the Technology Background section (see Section V), by 2013 wearable electronic devices, including finger rings, having sensors, processors, and transceivers was well-known.

c. Elements 16[a]/30[a]: obtaining, by the sensor of the sensor module, sensor data indicating a motion of the finger or a hand adjoined to the finger wearing the wearable computing device;

184. Sun teaches Elements 16[a]/30[a].

185. Sun teaches that its device detects the motion of the user's finger using motion sensors including an acceleration sensor and a gyroscope. Ex-1015 ¶¶24, 36. As Sun explains, its device has “sensors that *describe motion of the sensor in space*, including providing gesture data concerning up to 6 degrees of freedom, including 3 degrees of freedom in translation in linear space provided by an accelerometer and 3 degrees of freedom provided in rotation in angular space by a gyroscope.” *Id.* ¶36. These motion sensors are configured to sense motion of the hand or finger (which may be broken down into “displacement, velocity, and acceleration” components (*id.* ¶21)) occurring when a user wearing the finger mouse performs a given “gesture” (e.g., “tapping the chosen hand of the user on a surface”). *Id.* ¶8; *see also id.* Fig. 5 (Step 66).

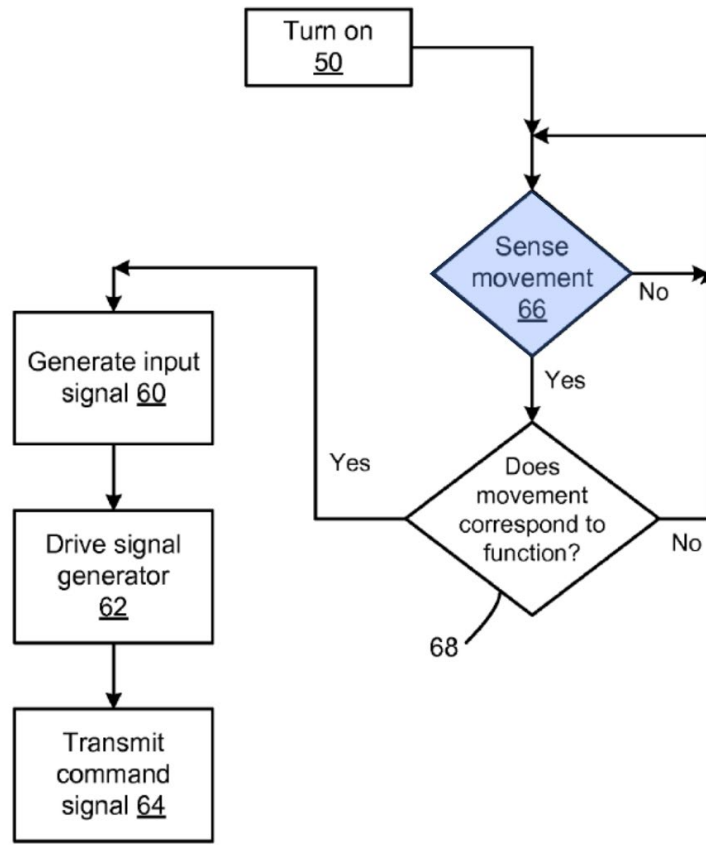


Fig. 5

186. As shown in the next element 16[b]/30[b], a number of gestures are defined using wrist movements (*id.* ¶42), but Sun teaches these are applicable to the finger mouse movements as well (*id.* ¶17 (“For ease of nomenclature, wrist/finger mouse 14 will typically be referred to as wrist mouse 14.”)).

187. As I explained in the Technology Background section (see Section V), by 2013 the use of motion sensors, such as accelerometers and gyroscopes, in wearable electronic devices, including those having finger ring form factors, was well-known. These sensors were commonly integrated into various form factors,

including those designed as finger rings. The integration of motion sensors in wearable devices allowed for the detection and interpretation of user movements, facilitating applications from health monitoring to gesture-based control interfaces.

d. Elements 16[b]/[30[b]]: comparing, by [one of the at least one] processor[s], the obtained sensor data to a predetermined pattern of motion;

188. Sun teaches Elements 16[b]/30[b].

189. Sun teaches that “[m]otion sensitive circuitry 32 comprises data processing resources which provide for interpretation of the gesture data received from motion sensor 24.” Ex-1015 ¶26. Sun further teaches that the motion sensitive circuitry within its device includes “comparator logic 37, for *comparing input sequences of data indicating gestures or component motions of gestures* that include a sequence of component motions, *with stored sequences of data specifying the unique signatures for memorized gestures* for component motions.” Ex-1015 ¶43; *see also id.*, Fig. 5 (Step 68). Sun’s exemplary predetermined patterns of motion are illustrated in the annotated excerpt below (blue). *Id.* ¶¶41-42.

GESTURE NUMBER	COMMAND GESTURE NAME	MAPS TO PRESENTATION COMMAND	MOTION DETECTION PROCESS
1.	Left and back movement	Left click	Motion to the left and back exceeding one or both of a threshold velocity or a threshold acceleration
2.	Right and black movement	Right-click	Motion to the right and back exceeding one or both of a threshold velocity or a threshold acceleration
3.	Left and back movement, then right and forward movement, then left and back movement	Double click	Motion along each leg exceeding one or both of a first threshold velocity or a first threshold acceleration and below one or both of a second threshold velocity or a second threshold acceleration
4.	Back movement, then right and forward movement, then forward movement	Begin drawing with cursor	Motion along each leg exceeding one or both of a first threshold velocity or a first threshold acceleration and below one or both of a second threshold velocity or a second threshold acceleration



**Predetermined
pattern**

e. Elements 16[c]/[30[c]]: determining, by [one of the at least one] processor[s], whether the obtained sensor data matches a predetermined pattern;

190. Sun teaches Elements 16[c]/30[c].

191. As shown in Figure 5 at step 68, Sun's device "*determines if the sensed movement corresponds to a predetermined function.*" Ex-1015 ¶44. Sun further

teaches that “comparator logic 37” within motion sensitive circuitry 32 compares the motion sensor data “with stored sequences of data specifying the unique signatures for memorized gestures for component motions”, to determine *whether the detected gesture matches a memorized gesture, stored in the library* (the claimed “predetermined pattern”). *Id.* ¶44; *see also id.* ¶19, Fig. 5.

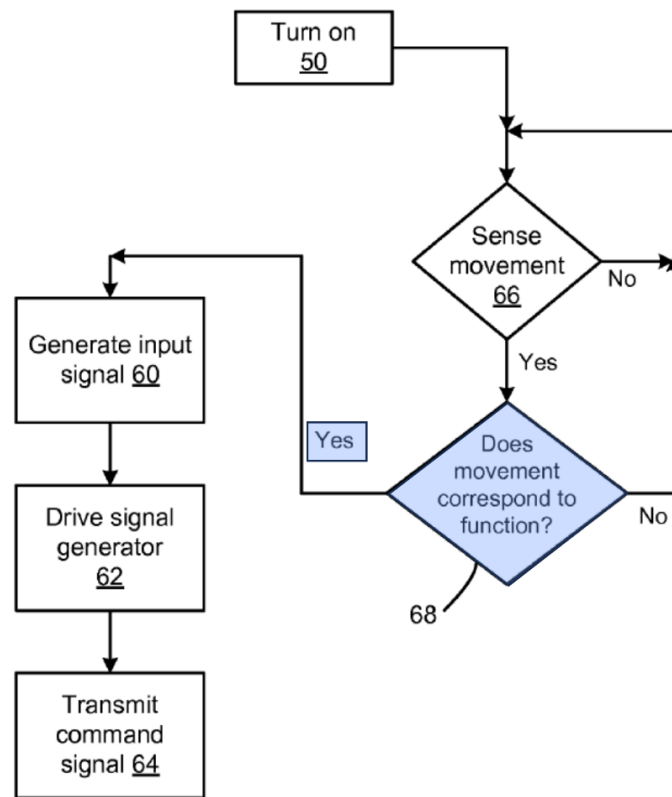


Fig. 5

192. Sun’s finger mouse thus determines whether the obtained motion sensor data matches a predetermined pattern stored in its “library of command []motions,” as shown below. Ex-1015 ¶¶31, 41-42.

GESTURE NUMBER	COMMAND GESTURE NAME	MAPS TO PRESENTATION COMMAND	MOTION DETECTION PROCESS
1.	Left and back movement	Left click	Motion to the left and back exceeding one or both of a threshold velocity or a threshold acceleration
2.	Right and black movement	Right-click	Motion to the right and back exceeding one or both of a threshold velocity or a threshold acceleration
3.	Left and back movement, then right and forward movement, then left and back movement	Double click	Motion along each leg exceeding one or both of a first threshold velocity or a first threshold acceleration and below one or both of a second threshold velocity or a second threshold acceleration
4.	Back movement, then right and forward movement, then forward movement	Begin drawing with cursor	Motion along each leg exceeding one or both of a first threshold velocity or a first threshold acceleration and below one or both of a second threshold velocity or a second threshold acceleration



**Corresponding
command**



**Predetermined
pattern**

193. As the second specific example above from Sun's gesture library shows, "a pre-specified gesture in the database can be defined as a movement of wrist mouse 14 back and to the right; this gesture can be associated with the right click function." *Id.* ¶31. Once the detected motion is determined to match the

pattern, the command shown in the middle column of the excerpt above is issued.

See id.

f. Elements 16[d]/[30[d]]: determining, by [one of the at least one] processor[s], a characteristic of an activity of the user of the wearable computing device when the obtained sensor data matches the predetermined pattern; and

194. Sun teaches Elements 16[d]/30[d].

195. While the '953 Patent specification does not define the term “characteristic of an activity of the user,” the specification states that the wearable computing device “can determine current activity of a user according to measurements taken by one or more sensors in the sensor module, such as accelerometer, gyroscope, magnetometer or digital compass.” Ex-1001, 42:64-67. A POSITA would have understood the plain and ordinary meaning of “characteristic of an activity of the user” to cover any property of the user’s motion or other activity. This includes, but is not limited to, parameters such as speed, direction, orientation, acceleration, rotational velocity, and spatial position. Furthermore, these characteristics are not limited to physical movements alone. They can also include other types of user activities that the sensors can detect. For example, a digital compass might be used to track the direction in which the user is facing, while a magnetometer could help in identifying specific gestures involving hand movements in relation to the Earth’s magnetic field.

196. Sun teaches determining an activity of the user, such as “a particular motion corresponding to a particular command.” Ex-1015 ¶19; *see also id.* ¶42 (listing several motions of the user that are determined when the sensor data matches the predetermined pattern, including translational (e.g., “Motion to the left and back...”) and rotational movements (e.g., “Rotate hand and wrist to the right...”) and tapping (e.g., “Sets of taps/pauses...”). As discussed above, these motions are measured by one or more sensors in Sun’s sensor module, such as the accelerometer and/or gyroscope. Ex-1015 ¶¶21, 24.

197. Sun further teaches that “[t]he gestures can be further defined by, for example, *smooth movements*, *short jerky movements* and accelerating-to-a-stop movements. Other types of or directions of movement can also be used.” Ex-1015 ¶26. Thus, Sun’s device has the ability to determine characteristics of a user’s motion, i.e., the claimed activity, including characteristics—such as whether the motion is smooth or jerky—in addition to just determining whether that particular motion, as defined by the sensor data, matches the predetermined pattern. A POSITA would have understood that these are characteristics of activities as described in the ’953 patent specification, e.g., the “current activity of a user according to measurements taken by one or more sensors in the sensor module, such as accelerometer.” Ex-1001, 42:64-66.

g. Element 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second

**data packet in response to a confirmation of the sensor
data matching the predetermined pattern.**

198. Sun teaches Elements 16[e]/30[e].

199. Sun teaches that the match between the sensed data and the predetermined pattern leads to a command signal to transmit the data to a remote device. Ex-1015 ¶19 (“Receipt of the ‘left click’ signal causes signal generator 30 create a ‘left click’ *command signal 16 for transmission to the signal receiver of computer 18.*”). See also *id.* ¶44 (if there is a match, “motion sensitive circuitry 32 generates input signal 28 at 60 for driving signal generator 30 at 62. Signal generator 30 then transmits a command signal 16 to the signal receiver of computer 18 as at 64.”); Fig. 5 (Steps 60, 62, 64).

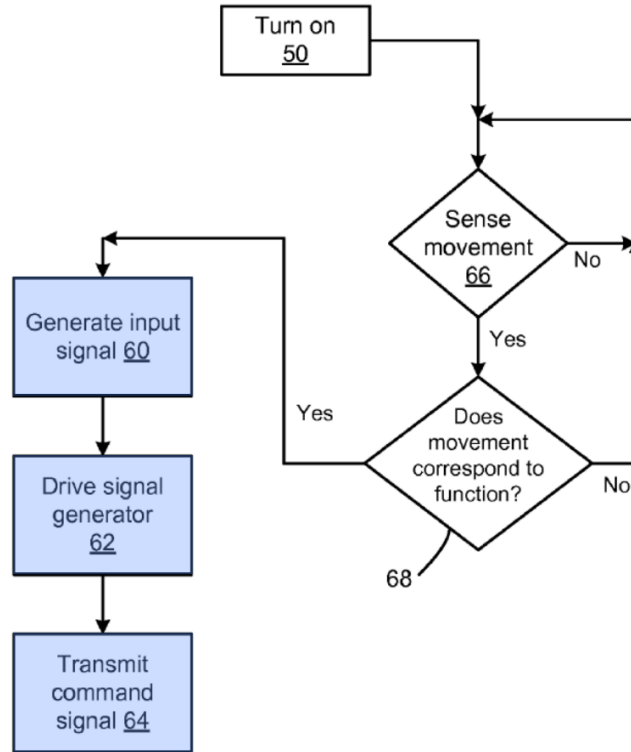


Fig. 5

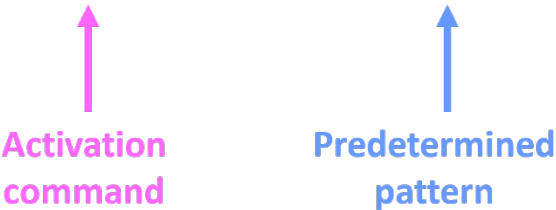
200. The transmission of the command signal in Sun’s finger mouse is done through “a communication port” (*id.* ¶24) that supports “communication protocols, such as wi-fi, Bluetooth or Zigbee, may be used.” *Id.* ¶18. Sun further teaches that “[c]ommand signals 16 can be any of a variety of wireless signals, and are typically RF command signals.” Ex-1015 ¶18. A POSITA would have understood that Sun’s teachings correspond to and would require a hardware transceiver in order to perform the transmission of the command signal to the external computer, and that in particular wi-fi, Bluetooth, and Zigbee are bi-directional communication protocols that require transceivers to communicate. A transceiver is a crucial

component that handles both the transmission and reception of wireless signals, ensuring effective bi-directional communication. A POSITA would have further understood that data transmitted under WiFi, Bluetooth, and Zigbee protocols is transmitted in data packets. Data packets are structured units of data that are transmitted over a network as part of a protocol, containing not only the actual data but also metadata, such as destination addresses and error-checking information. This packet-based transmission ensures efficient and reliable communication, allowing the device to send information and receive acknowledgments or additional instructions.

201. A POSITA would have also understood that Sun teaches activating the transceiver to transmit the command signal. For example, Sun teaches at least one gesture – Gesture #9 (“Rotate right”) – that causes the device to turn on, as shown in the excerpt annotated below. Ex-1015 ¶42.

-continued

GESTURE NUMBER	COMMAND GESTURE NAME	MAPS TO PRESENTATION COMMAND	MOTION DETECTION PROCESS
9.	Rotate right	Turns on wrist mouse	Rotate hand and wrist to the right (clockwise)
10.	Rotate left	Turns off wrist mouse	Rotate hand and wrist to the left (counterclockwise)



202. Further, Sun teaches that the device can have “a suspension mode, sometimes referred to as ‘go to sleep.’” *Id.* ¶37; *see also id.* ¶42 (disclosing Gesture #6, “Single tap on top side 80,” as corresponding to the “Go to sleep” command). A POSITA would have understood these disclosures to mean that a user could activate Sun’s device, including its transceiver to send or receive data, based on a gesture matching a predetermined pattern, such as Gesture #9 in Sun’s library.

203. As I explained in the Technology Background section (*see* Section V), it was understood by a POSITA in 2013 that electronic components like transceivers consume a significant amount of power. Transceivers, which enable wireless communication, are particularly power-hungry due to their continuous need to send and receive signals. By that time, it was also common knowledge to utilize “sleep” or low-power modes in wearable electronic devices. These modes are designed to

reduce power consumption by deactivating or minimizing the activity of power-intensive components when they are not in use. This involved activating their transceivers and other components only when necessary, in order to save energy and minimize the frequency of battery recharging. This approach to power management is crucial in wearable devices, which often have limited battery capacity and are expected to operate for extended periods between charges. By utilizing sleep modes, these devices can significantly extend their battery life, reducing the frequency of recharging and enhancing user convenience.

- 2. Dependent Claims 17/[31]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: determining that the sensor data matches the predetermined pattern based at least in part on a completion of the activity.**

204. Sun teaches Claims 17 and 31.

205. Sun teaches that its device's gesture recognition is partly based on the completion of the user's motion, i.e., the claimed activity. Ex-1015 ¶19.

206. As shown in example gesture 2 in Sun, the motion sensor data matched with the predetermined "right and back movement" involves "[m]otion to the right and back..." Ex-1015 ¶42.

GESTURE NUMBER	COMMAND GESTURE NAME	MAPS TO PRESENTATION COMMAND	MOTION DETECTION PROCESS
1.	Left and back movement	Left click	Motion to the left and back exceeding one or both of a threshold velocity or a threshold acceleration
2.	Right and black movement	Right-click	Motion to the right and back exceeding one or both of a threshold velocity or a threshold acceleration
3.	Left and back movement, then right and forward movement, then left and back movement	Double click	Motion along each leg exceeding one or both of a first threshold velocity or a first threshold acceleration and below one or both of a second threshold velocity or a second threshold acceleration
4.	Back movement, then right and forward movement, then forward movement	Begin drawing with cursor	Motion along each leg exceeding one or both of a first threshold velocity or a first threshold acceleration and below one or both of a second threshold velocity or a second threshold acceleration



**Predetermined
pattern**

207. A POSITA would have understood Sun's disclosure to mean that the matching with a predetermined pattern is based at least on the completion of the user's motion, i.e., completing the "and back" portion of the user's finger movement. Specifically, the recognition process requires the user to complete the "and back"

portion of the finger movement. This completion ensures that the gesture is fully executed, allowing the device to accurately match it with the stored gesture pattern.

- 3. Dependent Claims 18/[32]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising:] determining that the sensor data matches the predetermined pattern based at least in part on a start of the activity.**

208. Sun teaches Claims 18 and 32.

209. Sun teaches that its device's gesture recognition is partly based on the start of the user's motion, i.e., the claimed activity. Ex-1015 ¶19.

210. Further referencing the example shown as Gesture 2 in Sun, the motion sensor data matched with the predetermined "right and back movement" involves "[m]otion to the right and back..." Ex-1015 ¶42. A POSITA would have understood Sun's disclosure to mean that the matching with a predetermined pattern is based at least on the start of the user's motion, i.e., starting the "right" portion of the user's finger movement. Specifically, the recognition process begins with the start of the "right" portion of the finger movement. A POSITA would understand that by recognizing the start of the motion, Sun's device can promptly identify the intended gesture and begin processing it in real-time. This approach ensures that the device is responsive to the user's actions, providing immediate feedback and interaction. Early recognition of the gesture's start allows the device to anticipate the full motion, improving its ability to accurately match the gesture with stored

patterns.

4. Dependent Claim 20: The method of claim 16, wherein the sensor data further comprises an axial rotation measurement.

211. Sun teaches Claim 20.

212. Sun teaches that the gesture data in its device includes data in “3 degrees of freedom provided in rotation in angular space by a gyroscope,” which a POSITA would understand is an axial rotation measurement. Ex-1015 ¶36; *see also id.* ¶5 (“In some examples, the motion sensor comprises a translational, rotational, and vibrational movement motion sensor”); ¶21 (disclosing that the motion sensors are “capable of sensing up to 6 degrees of motion, including translation on the x-, y- and z-axes, and rotation on the x-, y- and z-axes.”). A POSITA would have understood this sensed rotational movement is used to identify rotational gestures based on wrist “turns.” Ex-1015 ¶42 (gesture number 9 and 10). This rotational data captures the device’s orientation changes along three rotational axes, offering comprehensive rotational-motion tracking. For instance, gestures involving specific rotational movements of the wrist, such as generally turning the wrist clockwise or counterclockwise, can be accurately detected and interpreted by the device.

5. Dependent Claims 21/[33]: The method of claim 16/[The non-transitory computer readable storage medium of claim 30], wherein the [at least one] sensor module comprises one or more of a light sensor, a gyroscope, and/or a magnetometer, and the sensor data further comprises a measurement from

one or more of the light sensor, a gyroscope, and/or a magnetometer.

213. Sun teaches Claims 21 and 33.

214. Sun teaches that its motion “sensors 24 include inertial sensors and gyroscopes capable of sensing up to 6 degrees of motion, including translation on the x-, y- and z-axes, and rotation on the x-, y-, and z-axes.” Ex-1015 ¶21. *See also id.* ¶36 (teaching that the “gesture data” includes data “in linear space provide by an accelerometer” and “in rotation in angular space by *a gyroscope*”).

215. As I explained in the Technology Background section (*see* Section V), using gyroscopes in wearable electronic devices, including finger rings, to obtain for example axial rotation measurements was well-known by a POSITA in 2013. Gyroscopes were often used in conjunction with accelerometers for additional versatility in detecting various motions, in particular for gesture recognition. For example, Mestas teaches that in its athletic monitoring device “[p]hysical gestures and movements may be detected using an accelerometer, a gyroscope and/or other sensors.” Ex-1010 ¶221 (Mestas). Bress’s gesture-recognition input device similarly teaches that its finger-ring motion sensors include gyroscopes. Ex-1016, Fig. 4 (Bress). The publication by Amma in 2010 also teaches the use of “gyroscopes for measuring angular velocity” in wearable input devices. Ex-1068, 2 (Amma). Similarly, Park noted in 2011 that “[r]ecently, hand-worn accelerometer and gyroscope sensor-based gesture recognition has been successfully used in

mobile and pervasive computing. This approach is appealing because it is low cost, low power, requires only lightweight processing, and can be implemented with compact form factors. Several projects have proposed gesture recognition systems based on a wide range of sensing form factors.” Ex-1070, 262 (Park). Park further explains that “while the accelerometer is often used in gesture recognition systems...recent research demonstrates that additional use of a gyroscope can improve gesture classification accuracy...by up to 4% because it can detect rotational movements.” *Id.*, 263.

216. As I also explained in the Technology Background section (*see* Section V), the use of magnetometers for motion sensing and gesture recognition was well-known by 2013. For example, Amma described that by 2010 “the technology of sensors is advancing significantly, allowing for very small, body-worn, wearable sensors...suitable for intuitive wearable computing systems. Traditionally used sensors, which are small and come at very reasonable costs are accelerometers, gyroscopes and magnetometers.” Ex-1068 at 1 (Amma).

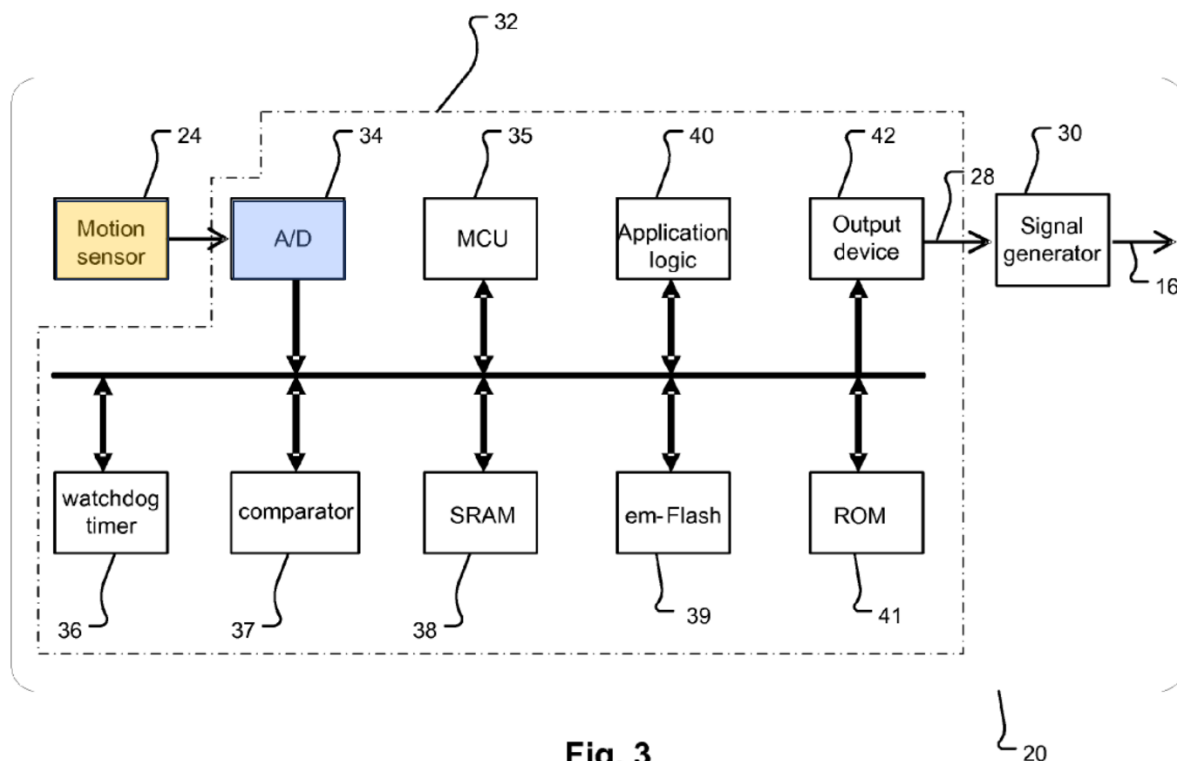
6. Dependent Claim 23 and 34

- a. Elements 23[pre/a]/[34[pre/a]]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: converting the sensor data into a series of samples;**

217. Sun teaches Elements 23[pre/a] and 34[pre/a].

218. Sun teaches that its gesture data is obtained as data sequences. Specifically, Sun teaches that its device “compar[es] input *sequences of data* indicating gestures or component motions of gestures that include a *sequence of component motions*.” Ex-1015 ¶43.

219. Sun’s device also includes an “analog-to-digital converter” (ADC) (denoted as “A/D” in Fig. 3). Ex-1015 ¶24, Fig. 3 (annotated below).



220. A POSITA would have understood that an ADC samples the analog signal from the motion sensor and converts the data into a series of digital samples, and that the data acquisition and processing in Sun is performed through a series of samples. This conversion process is basic and essential for data acquisition and

processing in Sun's device. By transforming the continuous analog signals into discrete digital samples, the ADC enables the device to analyze the gesture data the digital domain. The digital samples obtained from the ADC are then processed by the device to identify and interpret gestures. This process involves comparing the input sequences of digital data against stored gesture patterns to determine a match.

b. Elements 23[b]/34[b]: comparing the series of samples to the predetermined pattern; and

221. Sun teaches Elements 23[b]/34[b].

222. Sun teaches that its gesture data is obtained as data sequences and those data sequences are compared with “stored sequences of data specifying the unique signatures for memorized gestures.” Ex-1015 ¶43. As Sun teaches, its device “compar[es] input *sequences of data* indicating gestures or component motions of gestures that include a *sequence of component motions*, with *stored sequences of data* specifying the unique signatures for memorized gestures for component motions.” *Id.*.

223. The comparison of samples with the predetermined pattern is done through comparator 37 of the Sun device, shown in Figure 3 below (annotated).

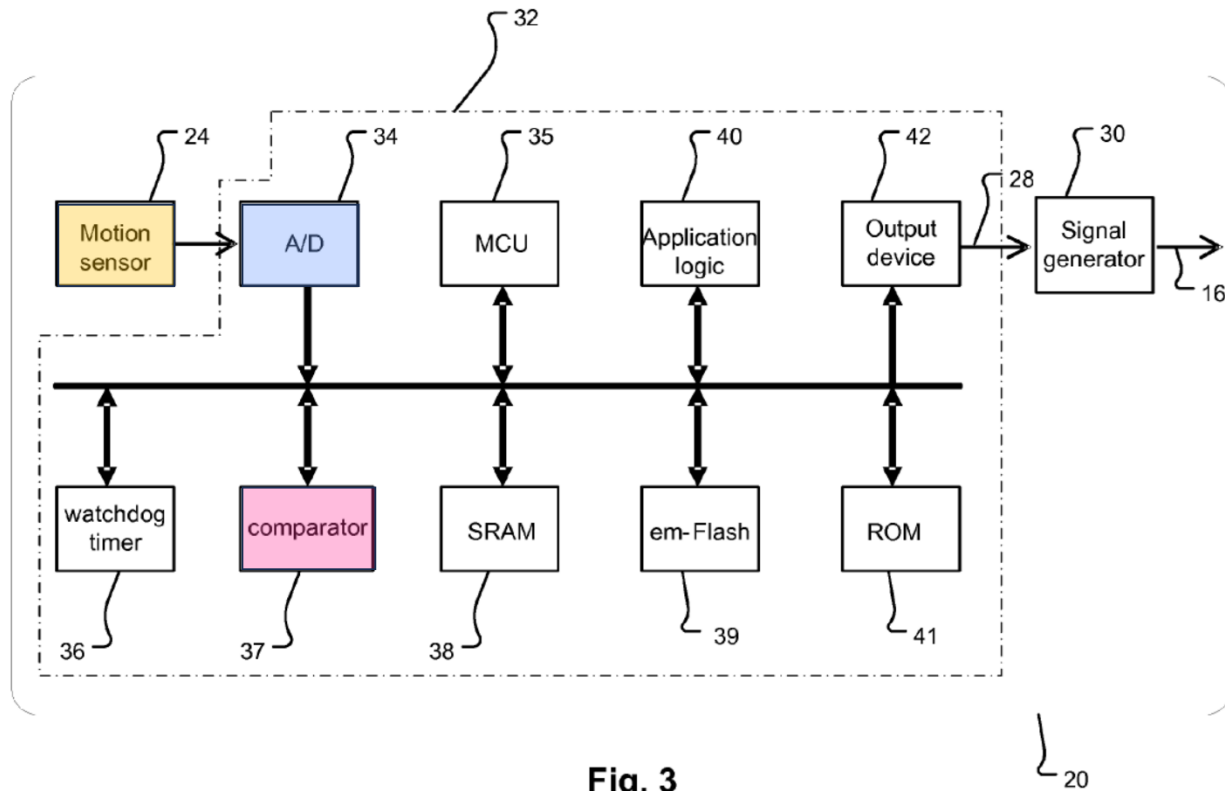


Fig. 3

224. As Sun explains, “comparator logic 37 [is] for comparing input sequences of data indicating gestures or component motions of gestures that include a sequence of component motions, with stored sequences of data specifying the unique signatures for memorized gestures for component motions.” Ex-1015 ¶43. A POSITA would have understood that because the data from Sun’s analog-to-digital converter is a series of samples, the comparison is done on the series of samples. The ADC converts the continuous analog signals from the motion sensors into discrete digital samples, which are then organized into sequences representing the gestures. These digital sequences are essential for the digital logic to function. For example, when a user performs a specific gesture, the motion sensors detect the

movement and generate corresponding analog signals. The ADC samples these signals at regular intervals, producing a sequence of digital data points that capture the gesture's characteristics. The comparator logic 37 then takes this sequence and compares it to the stored sequences of data representing memorized gestures. If a match is found, the device recognizes the gesture and executes the associated command.

c. Elements 23[c]/34[c]: determining that the sensor data matches the predetermined pattern if the series of samples matches the predetermined pattern.

225. Sun teaches Elements 23[c]/34[c].

226. Sun teaches that once there is a match with the predetermined pattern of sequences (“samples”), a signal is sent to a remote device, e.g., a computer. Ex-1015 ¶19 (“motion sensor 24 causes motion sensitive circuitry 32 to create a ‘left click’ input signal 28 to signal generator 30. Receipt of the ‘left click’ signal causes signal generator 30 create a ‘left click’ command signal 16 for transmission to the signal receiver of computer 18.”). A POSITA would have understood that Sun’s comparator logic 37 determines that the sensor data matched the predetermined pattern if the series of samples compared matched the predetermined pattern.

- 7. Dependent Claims 24/[35]: The method of claim 23, wherein/[The non-transitory computer readable storage medium of claim 34, wherein the processor further executes an operation comprising:] the comparing between the series of samples and the predetermined pattern is determined by a recognition technique.**

227. Sun teaches Claims 24 and 35.

228. Sun teaches that its device includes “*comparator logic* 37, for comparing input sequences of data indicating gestures,” which a POSITA would have understood teaches performing a recognition technique. Ex-1015 ¶43. Sun further teaches “application logic 40...in support of the gesture interpretation,” which would have bolstered a POSITA’s understanding that Sun teaches a recognition technique. Ex-1015 ¶43. A POSITA would recognize that the combined use of comparator logic and application logic in Sun’s device constitutes a sophisticated gesture recognition technique. The comparator logic performs the initial data comparison, identifying potential matches between the input data and stored gesture patterns. Once a match is detected, the application logic interprets the gesture’s significance and triggers the appropriate response or command.

229. As I explained in the Technology Background section (Section §V), recognition techniques were well-known by 2013, and virtually any gesture recognition application would have applied a recognition technique, where it be a simple template-matching/correlation or more complex techniques such as machine learning. By 2013, a range of pattern recognition methods were known. These methods ranged from simple template-matching and correlation techniques to more complex machine learning algorithms. Template-matching involves comparing input data to a set of predefined templates or patterns to find the closest match. This

technique is straightforward and effective for recognizing predefined gestures or shapes. More advanced techniques, such as machine learning, involve training algorithms on large datasets to recognize and differentiate between various patterns or gestures. Machine learning models, such as neural networks, can learn from data and improve their recognition accuracy over time.

8. Dependent Claim 37

a. Elements 37[pre/a]: The non-transitory computer readable storage medium of claim 30, wherein the processor further executes operations comprising: converting the sensor data into at least one direction vector;

230. Sun teaches Elements 37[pre/a].

231. Sun teaches that its motion sensors are “capable of sensing up to 6 degrees of motion, including translation on the x-, y- and z-axes, and rotation on the x-, y- and z-axes.” Ex-1015 ¶21. Sun further teaches that the device can “sense up and down direction” and may also determine “right and left lateral directions.” Ex-1015 ¶30. It further teaches that “[o]ther schemes for determining orientation and movements may also be used.” *Id.* A POSITA would have understood these teachings to disclose converting the sensor data into at least one direction vector. A POSITA would have understood that the use of direction vectors allows the device to represent the detected motion in a simplified and actionable form. The ability to generate direction vectors from motion sensor data enhances the device's flexibility

and accuracy. It allows the device to interpret complex gestures involving multiple axes of movement, providing a more intuitive and responsive user experience.

b. Element 37[b]: detecting a characteristic of an orientation changes of the wearable computing device based at least in part on the at least one direction vector;

232. Sun teaches Element 37[b].

233. Sun teaches that its device can detect changes in orientation, such as rotation. *See* Ex-1015 ¶27 (describing “[r]otation of the user’s hand to the right,” a “clockwise roll or longitudinal or x-axis clockwise rotation.”); ¶42 (disclosing “Rotate right” and “Rotate left” gestures). A POSITA would have understood that these rotations would involve orientation changes based at least on one direction vector. These rotation-based orientation changes disclosed by Sun are similar to the orientation changes described in the ’953 patent specification as arising from the rotation of a direction vector tied to the finger ring around its center axis. *See* Ex-1001, 45:24-46. In both cases, the detection and interpretation of rotational movements are crucial for accurately recognizing and responding to user gestures. The ability to detect and interpret rotational movements enhances the functionality of the device. By accurately sensing rotations, the device can recognize a wide range of gestures that involve twisting or turning motions.

c. Element 37[c]: comparing the characteristics of the detected orientation changes to the predetermined pattern; and

234. Sun teaches Element 37[c].

235. Sun teaches that the characteristics of the detected orientation changes are compared to the predetermined pattern. Ex-1015 ¶42 (see excerpt annotated below, describing “Rotate right” and “Rotate left” command gesture names as corresponding to two predetermined gestures involving rotation, and which a POSITA would have understood involve comparing orientation changes).

-continued

GESTURE NUMBER	COMMAND GESTURE NAME	MAPS TO PRESENTATION COMMAND	MOTION DETECTION PROCESS
9.	Rotate right	Turns on wrist mouse	Rotate hand and wrist to the right (clockwise)
10.	Rotate left	Turns off wrist mouse	Rotate hand and wrist to the left (counterclockwise)
11.	Move forward	Causes image on display of computer to zoom in	Move wrist mouse away from the user generally parallel to longitudinal movement line 72
12.	Move backward	Causes image on the display of computer to zoom out	Move wrist mouse towards the user generally parallel to longitudinal movement line 72


**Predetermined
pattern**

d. Element 37[d]: determining whether the sensor data matches the predetermined pattern.

236. Sun teaches Element 37[d].

237. Sun teaches that its device determines whether the sensor data matches

predetermined pattern. Ex-1015 ¶42 (describing “Rotate right” and “Rotate left” command gestures as corresponding to two predetermined patterns that detected motion sensor data is compared against); ¶44 (describing “determin[ing] if the sensed movement corresponds to a predetermined function as at 68.”); Fig. 5.

B. Ground 2: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun in View of Bress

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

238. A POSITA would have been motivated to combine Sun’s and Bress’s teachings and would have had a reasonable expectation of success because each relates to the same well-known technologies. Sun and Bress are both directed to wearable biometric sensing devices for gesture recognition, and their devices are both worn on the finger and include similar components, such as motion sensors and processors. Ex-1015 ¶18 (motion sensor), ¶43 (processor); Ex-1016, Abstract, 6:13-16 (motion sensor), 14:45-65 (processor). Further, both Sun’s and Bress’s devices have a “sleep mode.” Ex-1015 ¶37; Ex-1016, 15:62-64.

239. A POSITA would have been motivated to implement Bress’s particular “sleep” mode functionality—including activating the transceiver when certain gestures are detected—in Sun’s device because a POSITA would have recognized the energy savings this functionality would bring, as described in Bress. A POSITA would have recognized that transceivers are high power components, which ideally

should operate only when needed, rather than constantly being on. The ability to wake up the transceiver from the “sleep” mode by using a gesture as disclosed in Bress—would significantly extend the battery life of the Sun device while maintaining convenience, making it more practical for everyday use without the need for frequent recharging. This is particularly important for wearable technology, especially of small form factors, where the battery is small and battery life is a critical factor in user satisfaction and device usability. The addition of a sleep mode where high power components are deactivated and could be activated by particular gestures would have served as an important, differentiating feature in a crowded market, providing a competitive edge by addressing one of the common pain points of wearable devices—battery life. Additionally, the implementation of a gesture-activated sleep mode aligns with the growing trend towards more intuitive and user-friendly interfaces in (wearable) technology. Users expect their devices to be smart and responsive, with features that enhance convenience and efficiency. The ability to control power states with simple gestures not only meets these expectations but also adds a layer of sophistication to the device’s functionality.

240. And while a POSITA would have understood that Sun’s finger mouse is “in the form factor of a ring for being worn around the finger,” Bress explicitly teaches that its “device’s finger sensors are in rings.” Ex-1016, 6:13-16; *see also id.*, 7:57-58 (“FIG. 1 depicts a user wearing an Imagine where the finger sensors are

contained in solid rings.”), Fig. 1. A POSITA would have been motivated to implement Bress’s finger ring design with Sun’s finger mouse device, as a POSITA would have realized several benefits of a finger ring, including longer-term wearability and minimal interference with the user’s daily activities as well as the less bulky, more natural profile, and more fashionable design of a finger ring. A POSITA would also have realized that integrating new functionalities that are not traditionally associated with jewelry, such as electronic device control, into a finger ring would have led a POSITA to explore the use of a finger ring, as disclosed in Bress, as a versatile and modern alternative to Sun’s finger mouse. Thus, design incentives and market forces would have motivated a POSITA to apply Bress’s teachings to Sun’s finger mouse device. The concept of a finger ring as a versatile and modern alternative to traditional wearable devices aligns with trends in wearable technology. Consumers were increasingly looking for devices that provide advanced features without compromising on style or convenience. By implementing Bress’s finger ring design, Sun’s finger mouse device could capitalize on this trend, offering a product that is both technologically advanced and aesthetically pleasing. The innovative combination of jewelry and electronic device control could attract fashion-conscious consumers who seek both functionality and style in their wearable devices.

241. A POSITA would have had a reasonable expectation of success in

combining Sun and Bress, which are analogous prior art as they both involve finger-worn biometric sensing devices with gesture recognition capabilities having similar structural components. A POSITA would have understood that the electronic components of Sun's and Bress's gesture recognition devices are similar such that they are programmable using standard processors and are interchangeable. *Id.* A POSITA would have understood that these references disclose interrelated teachings based on routine technologies amenable to various well-understood and predictable combinations to provide more features and enhance user interest. *Id.*

2. Independent Claims 16 and 30

- a. Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and**

242. Sun-Bress teaches Elements 16[pre(1)]/30[pre(1)], to the extent they are limiting.

243. As discussed at Ground 1, Sun teaches a method adapted to a wearable computing device and a non-transitory readable storage medium storing instructing for implementation by a processor of such a device. *Supra* §VIII.A.1.a.

244. While a POSITA would have understood, as discussed at Ground 1

(§VIII.A.1.a), that Sun’s finger mouse is “in the form factor of a ring for being worn around the finger,” Bress explicitly teaches that its “device’s finger sensors are in rings.” Ex-1016, 6:13-16; *see also id.*, 7:57-58 (“FIG. 1 depicts a user wearing an Imagine where the finger sensors are contained in solid rings.”), Fig. 1.

245. A POSITA would have been motivated to combine Sun’s and Bress’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.B.1.

b. Elements 16[pre(2)]/30[pre(2)]

246. Sun-Bress teaches Elements 16[pre(2)]/30[pre(2)], to the extent they are limiting, at least because Sun teaches them, as discussed at Ground 1. *Supra* §VIII.A.1.b.

c. Elements 16[a]/30[a]

247. Sun-Bress teaches Elements 16[a]/30[a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.c.

d. Elements 16[b]/30[b]

248. Sun-Bress teaches Elements 16[b]/30[b] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.d.

e. Elements 16[c]/30[c]

249. Sun-Bress teaches Elements 16[c]/30[c] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.e.

f. Elements 16[d]/[30[d]]

250. Sun-Bress teaches Elements 16[d]/30[d] at least because Sun teaches them, as discussed at Ground 1. §.

g. Elements 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.

251. Sun-Bress teaches Elements 16[e]/30[e] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.g.

252. In addition to Sun’s disclosures discussed at Ground 1, Bress expressly teaches a transceiver, including a “WiFi transceiver 406” and a “Bluetooth Transceiver 405.” Ex-1016, 13:65-66, 14:3-5. Bress further teaches activating the transceiver to transmit a data packet in response to a confirmation of the sensor data matching the predetermined pattern. Bress further teaches that “[e]nergy management is critical in wireless devices” and that its device has a low-power or “sleep” mode. Ex-1016, 15:61-64. In the “sleep” mode, “many of the subsystems may be shut down,” including “[a]ny and all of the communications channels, such as BlueTooth...and WiFi.” *Id.*, 16:3-7. The processor polls the sensors, including motion sensors and “[s]ensor data during the brief awake times would determine if there is any need to stay awake to verify a change of state, resume sleep, or fully wake up.” *Id.*, 16:8-14. A POSITA would have been motivated to use the ability to wake up from “sleep” mode as taught by Bress in Sun’s device to conserve energy

by keeping transceiver operations to a minimum. A POSITA would have understood that the processor could poll motion sensor data in the “sleep” mode and wake up or “activate” the transceiver to transmit a data packet to the external device, e.g., a command corresponding to a particular gesture, if the sensor data matched a predetermined pattern.

253. As I explained in the Technology Background section (*see* Section V), it was understood by a POSITA in 2013 that electronic components like transceivers consume a significant amount of power. Transceivers, which enable wireless communication, are particularly power-hungry due to their continuous need to send and receive signals. By that time, it was also common knowledge to utilize “sleep” or low-power modes in wearable electronic devices. These modes are designed to reduce power consumption by deactivating or minimizing the activity of power-intensive components when they are not in use. This involved activating their transceivers and other components only when necessary, in order to save energy and minimize the frequency of battery recharging. This approach to power management is crucial in wearable devices, which often have limited battery capacity and are expected to operate for extended periods between charges. By utilizing sleep modes, these devices can significantly extend their battery life, reducing the frequency of recharging and enhancing user convenience.

254. A POSITA would have been motivated to combine Sun’s teachings

with Bress's teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.B.1.

3. Dependent Claims 17/31

255. Sun-Bress teaches Claims 17 and 31 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.2.

4. Dependent Claims 18/32

256. Sun-Bress teaches Claims 18 and 32 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.3.

5. Dependent Claim 20

257. Sun-Bress teaches Claim 20 at least because Sun teaches it, as discussed at Ground 1. §VIII.A.4.

6. Dependent Claims 21/33

258. Sun-Bress teaches Claims 21 and 33 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.5.

7. Dependent Claim 23 and 34

a. Elements 23[pre/a]/34[pre/a]

259. Sun-Bress teaches Elements 23[pre/a] and 34[pre/a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.a.

a. Elements 23[b]/34[b]

260. Sun-Bress teaches Elements 23[b]/34[b] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.b.

a. Elements 23[c]/34[c]

261. Sun-Bress teaches Elements 23[c]/34[c] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.c.

8. Dependent Claims 24 / 35

262. Sun-Bress teaches Claims 24 and 35 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.7.

9. Dependent Claim 37

a. Elements 37[pre/a]

263. Sun-Bress teaches Elements 37[pre/a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.8.a.

a. Element 37[b]

264. Sun-Bress teaches Element 37[b] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.b.

a. Element 37[c]

265. Sun-Bress teaches Element 37[c] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.c.

a. Element 37[d]

266. Sun-Bress teaches Element 37[d] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.d.

C. Ground 3: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun in View of Asami

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

267. A POSITA would have been motivated to combine Sun's and Asami's teachings and would have had a reasonable expectation of success because each relates to the same well-known technologies. Sun and Asami are both directed to finger-worn wearable biometric sensing devices for gesture recognition, have finger ring form factors, and include similar components, such as motion sensors and processors. Ex-1015 ¶24 (accelerometer), ¶43 (processor); Ex-1014 ¶73 (motion sensor), ¶65 (processor).

268. While a POSITA would have understood that Sun's finger mouse is "in the form factor of a ring for being worn around the finger," Asami explicitly teaches that the components of its device are "provided in *a finger ring body 10* made of resin as an annular body," forming "the [] wearable input device 1." Ex-1014 ¶44.

269. A POSITA would have been motivated to implement Asami's finger ring design with Sun's finger mouse device, as a POSITA would have realized several benefits of a finger ring, including longer-term wearability and minimal interference with the user's daily activities as well as the less bulky, more natural profile, and more fashionable design of a finger ring. A POSITA would also have realized that integrating new functionalities that are not traditionally associated with jewelry, such as electronic device control, into a finger ring would have led a

POSITA to explore the use of Asami's finger ring as a versatile and modern alternative to Sun's finger mouse. The market for wearable technology is highly competitive, with numerous devices offering similar functionalities. Incorporating Asami's finger ring design into Sun's finger mouse device would provide a unique selling point, differentiating it from competitors. Consumers increasingly look for devices that provide advanced features without compromising on style or convenience. By implementing Asami's finger ring design, Sun's finger mouse device could capitalize on this trend, offering a product that is both technologically advanced and aesthetically pleasing.

270. A POSITA would have had a reasonable expectation of success in combining Sun and Asami, which are analogous prior art as they both involve finger-worn biometric sensing devices with gesture recognition capabilities having similar structural components. A POSITA would have understood that the electronic components of Sun's and Asami's gesture recognition devices are similar such that they are programmable using standard processors and are interchangeable. A POSITA would have understood that these references disclose interrelated teachings based on routine technologies amenable to various well-understood and predictable combinations to provide more features and enhance user interest.

2. Independent Claims 16 and 30

- a. Element 16

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(1)
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: A method, adapted to a wearable computing device in the form factor of a ring for being**

worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and

271. Sun-Asami teaches Elements 16[pre(1)]/30[pre(1)], to the extent they are limiting.

272. As discussed at Ground 1, Sun teaches a method adapted to a wearable computing device and a non-transitory readable storage medium storing instructing for implementation by a processor of such a device. *Supra* §VIII.A.1.a.

273. While a POSITA would have understood, as discussed at Ground 1 (§VIII.A.1.a), that Sun’s finger mouse is “in the form factor of a ring for being worn around the finger,” Asami expressly teaches its device is a finger ring. In particular, Asami teaches that its device includes electronic components “provided in *a finger ring body 10* made of resin as an annular body,” forming “the [] wearable input device 1.” Ex-1014 ¶44, Fig. 1B.

274. A POSITA would have been motivated to combine Sun’s and Asami’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.C.1.

b. Elements 16[pre(2)]/30[pre(2)]:

275. Sun-Asami teaches Elements 16[pre(2)]/30[pre(2)], to the extent they

are limiting, at least because Sun teaches them, as discussed at Ground 1. *Supra* §VIII.A.1.b.

c. Elements 16[a]/30[a]

276. Sun-Asami teaches Elements 16[a]/30[a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.c.

d. Elements 16[b]/30[b]

277. Sun-Asami teaches Elements 16[b]/30[b] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.d.

e. Elements 16[c]/30[c]

278. Sun-Asami teaches Elements 16[c]/30[c] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.e.

f. Elements 16[d]/30[d]

279. Sun-Asami teaches Elements 16[d]/30[d] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.f.

g. Elements 16[e]/30[e]

280. Sun-Asami teaches Elements 16[e]/30[e] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.g.

3. Dependent Claims 17/31

281. Sun-Asami teaches Claims 17 and 31 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.2.

4. Dependent Claims 18/32

282. Sun-Asami teaches Claims 18 and 32 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.3.

5. Dependent Claim 20

283. Sun-Asami teaches Claim 20 at least because Sun teaches it, as discussed at Ground 1. §VIII.A.4.

6. Dependent Claims 21/33

284. Sun-Asami teaches Claims 21 and 33 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.5.

7. Dependent Claim 23 and 34

a. Elements 23[pre/a]/34[pre/a]

285. Sun-Asami teaches Elements 23[pre/a] and 34[pre/a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.a.

b. Elements 23[b]/34[b]

286. Sun-Asami teaches Elements 23[b]/34[b] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.b.

c. Elements 23[c]/34[c]

287. Sun-Asami teaches Elements 23[c]/34[c] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.c.

8. Dependent Claims 24/35

288. Sun-Asami teaches Claims 24 and 35 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.7.

9. Dependent Claim 37

a. Elements 37[pre/a]

289. Sun-Asami teaches Elements 37[pre/a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.8.a.

b. Element 37[b]

290. Sun-Asami teaches Element 37[b] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.b.

c. Element 37[c]

291. Sun-Asami teaches Element 37[c] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.c.

d. Element 37[d]

292. Sun-Asami teaches Element 37[d] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.d.

D. Ground 4: Claims 16-18, 20-21, 23-24, 30-35, and 37 Are Obvious Over Sun in View of Asami and Further in View of Bress

1. A POSITA would have been motivated to combine Sun-Asami's teachings with Bress's teachings and would have had a reasonable expectation of success

293. A POSITA would have been motivated to combine Sun-Asami's teachings with Bress's teachings and would have had a reasonable expectation of success because each relates to the same well-known technologies. Sun, Asami, and Bress are all directed to wearable biometric sensing devices for gesture recognition, have finger ring form factors, and include similar components, such as motion

sensors and processors. Ex-1015 ¶23 (accelerometer), ¶43 (processor); Ex-1014 ¶73 (motion sensor), ¶65 (processor); Ex-1016, Abstract, 6:13-16 (motion sensor), 14:45-65 (processor). Further, both Sun's and Bress's devices have a "sleep mode." Ex-1015 ¶37; Ex-1016, 15:62-64.

294. A POSITA would have been motivated to implement Bress's "sleep" mode functionality to Sun-Asami's device because a POSITA would have recognized the energy savings that the "sleep" mode would bring, as described in Bress. The inclusion of a "sleep" mode—and the ability to wake up from the "sleep" mode by using a gesture as disclosed in Bress—would significantly extend the battery life of the Sun-Asami device while maintaining convenience, making it more practical for everyday use without the need for frequent recharging. This is particularly important for wearable technology, especially of small form factors, where the battery is small and battery life is a critical factor in user satisfaction and device usability. The addition of a sleep mode would have served as an important, differentiating feature in a crowded market, providing a competitive edge by addressing one of the common pain points of wearable devices—battery life. Thus, design incentives and market forces would have motivated a POSITA to apply Bress's teachings to the Sun-Asami device. Additionally, the implementation of a gesture-activated sleep mode aligns with the growing trend towards more intuitive and user-friendly interfaces in (wearable) technology. Users expect their devices to

be smart and responsive, with features that enhance convenience and efficiency. The ability to control power states with simple gestures not only meets these expectations but also adds a layer of sophistication to the device's functionality.

295. A POSITA would have had a reasonable expectation of success in combining Sun-Asami and Bress, which are analogous prior art as they both involve biometric sensing devices with gesture recognition capabilities having similar structural components. A POSITA would have understood that the electronic components of Sun-Asami's and Bress's gesture recognition devices are similar such that they are programmable using standard processors and are interchangeable. *Id.* A POSITA would have understood that these references disclose interrelated teachings based on routine technologies amenable to various well-understood and predictable combinations to provide more features and enhance user interest. *Id.*

2. Independent Claims 16 and 30

- a. **Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and**

296. Sun-Asami-Bress teaches Elements 16[pre(1)]/30[pre(1)], to the extent they are limiting.

297. As discussed at Ground 1, Sun teaches a method adapted to a wearable computing device and a non-transitory readable storage medium storing instructing for implementation by a processor of such a device. *Supra* §VIII.A.1.a.

298. While a POSITA would have understood, as discussed at Ground 1 (§VIII.A.1.a), that Sun’s finger mouse is “in the form factor of a ring for being worn around the finger,” Asami expressly teaches that its device includes electronic components “provided in *a finger ring body 10* made of resin as an annular body,” forming “the [] wearable input device 1.” Ex-1014 ¶44, Fig. 1B. Bress also explicitly teaches that its “device’s finger sensors are in rings.” Ex-1016, 6:13-16; *see also id.*, 7:57-58 (“FIG. 1 depicts a user wearing an Imagine where the finger sensors are contained in solid rings.”), Fig. 1.

299. A POSITA would have been motivated to combine Sun’s, Asami’s, and Bress’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.D.1.

b. Element 16[pre(2)]/30[pre(2)]:

300. Sun-Asami-Bress teaches Elements 16[pre(2)]/30[pre(2)], to the extent they are limiting, at least because Sun teaches them, as discussed at Ground 1. *Supra* §VIII.A.1.b.

c. Elements 16[a]/30[a]

301. Sun-Asami-Bress teaches Elements 16[a]/30[a] at least because Sun

teaches them, as discussed at Ground 1. §VIII.A.1.c.

d. Elements 16[b]/[30[b]]

302. Sun-Asami-Bress teaches Elements 16[b]/30[b] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.d.

e. Elements 16[c]/[30[c]]

303. Sun-Asami-Bress teaches Elements 16[c]/30[c] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.e.

f. Elements 16[d]/[30[d]]

304. Sun-Asami-Bress teaches Elements 16[d]/30[d] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.f.

g. Element 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.

305. Sun-Asami-Bress teaches Elements 16[e]/30[e] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.1.g.

306. In addition to Sun's disclosures discussed at Ground 1, Bress expressly teaches a transceiver, including a "WiFi transceiver 406" and a "Bluetooth Transceiver 405." Ex-1016, 13:65-66, 14:3-5. Bress further teaches activating a transceiver to transmit a data packet in response to a confirmation of the sensor data matching the predetermined pattern. Bress teaches that "[e]nergy management is critical in wireless devices" and that its device has a low-power or "sleep" mode.

Ex-1016, 15:61-64. In the “sleep” mode, “many of the subsystems may be shut down,” including “[a]ny and all of the communications channels, such as BlueTooth...and WiFi.” *Id.*, 16:3-7. The processor polls the sensors, including motion sensors and “[s]ensor data during the brief awake times would determine if there is any need to stay awake to verify a change of state, resume sleep, or fully wake up.” *Id.*, 16:8-14. A POSITA would have been motivated to use the ability to wake up from “sleep” mode as taught by Bress in the Sun-Asami device to conserve energy by keeping transceiver operations to a minimum. A POSITA would have understood that the processor could poll motion sensor data in the “sleep” mode and wake up the transceiver to transmit a data packet to the external device, e.g., a command corresponding to a particular gesture, if the sensor data matched a predetermined pattern.

307. A POSITA would have been motivated to combine Sun-Asami’s teachings with Bress’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.D.1.

3. Dependent Claims 17/31

308. Sun-Asami-Bress teaches Claims 17 and 31 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.2.

4. Dependent Claims 18/32

309. Sun-Asami-Bress teaches Claims 18 and 32 at least because Sun

teaches them, as discussed at Ground 1. §VIII.A.3.

5. Dependent Claim 20

310. Sun-Asami-Bress teaches Claim 20 at least because Sun teaches it, as discussed at Ground 1. §VIII.A.4.

6. Dependent Claims 21/33

311. Sun-Asami-Bress teaches Claims 21 and 33 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.5.

7. Dependent Claim 23 and 34

a. Elements 23[pre/a]/[34[pre/a]]

312. Sun-Asami-Bress teaches Elements 23[pre/a] and 34[pre/a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.a.

b. Elements 23[b]/34[b]

313. Sun-Asami-Bress teaches Elements 23[b]/34[b] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.b.

c. Elements 23[c]/34[c]

314. Sun-Asami-Bress teaches Elements 23[c]/34[c] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.6.c.

8. Dependent Claims 24/35

315. Sun-Asami-Bress teaches Claims 24 and 35 at least because Sun teaches them, as discussed at Ground 1. §VIII.A.7.

9. Dependent Claim 37

a. Elements 37[pre/a]

316. Sun-Asami-Bress teaches Elements 37[pre/a] at least because Sun teaches them, as discussed at Ground 1. §VIII.A.8.a.

b. Element 37[b]

317. Sun-Asami-Bress teaches Element 37[b] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.b.

c. Element 37[c]

318. Sun-Asami-Bress teaches Element 37[c] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.c.

d. Element 37[d]

319. Sun-Asami-Bress teaches Element 37[d] at least because Sun teaches it, as discussed at Ground 1. §VIII.A.8.d.

E. Ground 5: Claims 16-18, 23-24, 30-32, and 34-35 Are Obvious Over Asami in View of Bress

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

320. A POSITA would have been motivated to combine Asami's and Bress's teachings and would have had a reasonable expectation of success because each relates to the same well-known technologies. Asami and Bress are both directed to wearable biometric sensing devices for gesture recognition, have finger ring form factors, and include similar components, such as motion sensors and

processors. Ex-1014 ¶44 (finger ring), ¶73 (motion sensor), ¶65 (processor); Ex-1016, Abstract (Motion sensor), 6:13-16 (finger ring), 14:45-65 (processor). And while Asami's device has a "radio transmitter 23" (Ex-1014 ¶65) for sending data to an external device, Bress teaches a transceiver, including a "WiFi transceiver 406" and a "Bluetooth Transceiver 405." Ex-1016, 13:65-66, 14:3-5. In the "sleep" mode, "many of the subsystems may be shut down," including "[a]ny and all of the communications channels, such as BlueTooth...and WiFi." *Id.*, 16:3-7.

321. A POSITA would have been motivated to implement Bress's transceiver and "sleep" mode functionality to Asami's device. A POSITA would have appreciated the additional capability of being able to not only transmit, but also receive data in Asami's device. And a POSITA would have recognized the energy savings that Bress's "sleep" mode would bring. The inclusion of a "sleep" mode would significantly extend the battery life of the Asami device, making it more practical for everyday use without the need for frequent recharging. This is particularly important for wearable technology, especially of small form factors, where the battery is small and battery life is a critical factor in user satisfaction and device usability. The addition of a sleep mode would have served as an important, differentiating feature in a crowded market, providing a competitive edge by addressing one of the common pain points of wearable devices—battery life. Thus, design incentives and market forces would have motivated a POSITA to apply

Bress's teachings to Asami's finger ring device.

322. A POSITA would have had a reasonable expectation of success in combining Asami and Bress, which are analogous prior art as they both involve biometric sensing devices with gesture recognition capabilities having similar structural components. A POSITA would have understood that the electronic components of Asami's and Bress's gesture recognition devices are similar such that they are programmable using standard processors. A POSITA would have understood that these references disclose interrelated teachings based on routine technologies amenable to various well-understood and predictable combinations to provide more features and enhance user interest.

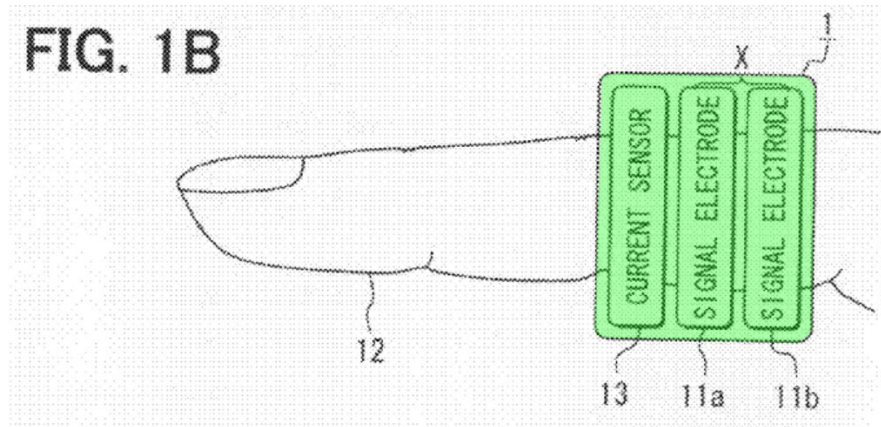
2. Independent Claims 16 and 30

- a. Element 16[pre(1)]: A method, adapted to a wearable computing device in the form factor of a ring for being worn around the finger of a user, / Element 30[pre(1)]: A non-transitory computer readable storage medium storing computer readable instructions for implementation by a processor of a wearable computing device, the wearable computing device being in the form factor of a ring for being worn around the finger of a user and**

323. To the extent the preamble is limiting, Asami-Bress teaches Elements 16[pre(1)]/30[pre(1)].

324. Asami teaches a method adapted to a "wearable input device." *E.g.*, Ex-1014, Abstract. Asami's device includes electronic components "provided in *a*

finger ring body 10 made of resin as an annular body, which forms the outer shape of the...wearable input device 1.” Ex-1014 ¶44. Asami further teaches that the electronic components of the device “are integrated...*in the finger ring body 10.*” *Id.* ¶44, Fig. 1A, Fig. 1B, reproduced below.



325. Asami’s “wearable input device” includes “an *analyzer unit 21*,” which has a “*built-in memory 21a*.” *Id.* ¶¶65, 75. As explained more fully below, a POSITA would have understood that Asami’s “analyzer unit” is a processor that performs computer operations (Ex-1014 ¶¶76-77), and that Asami’s “built-in memory” is a non-transitory computer readable storage medium that contains instructions for performing those operations. *Id.* ¶¶75, 107.

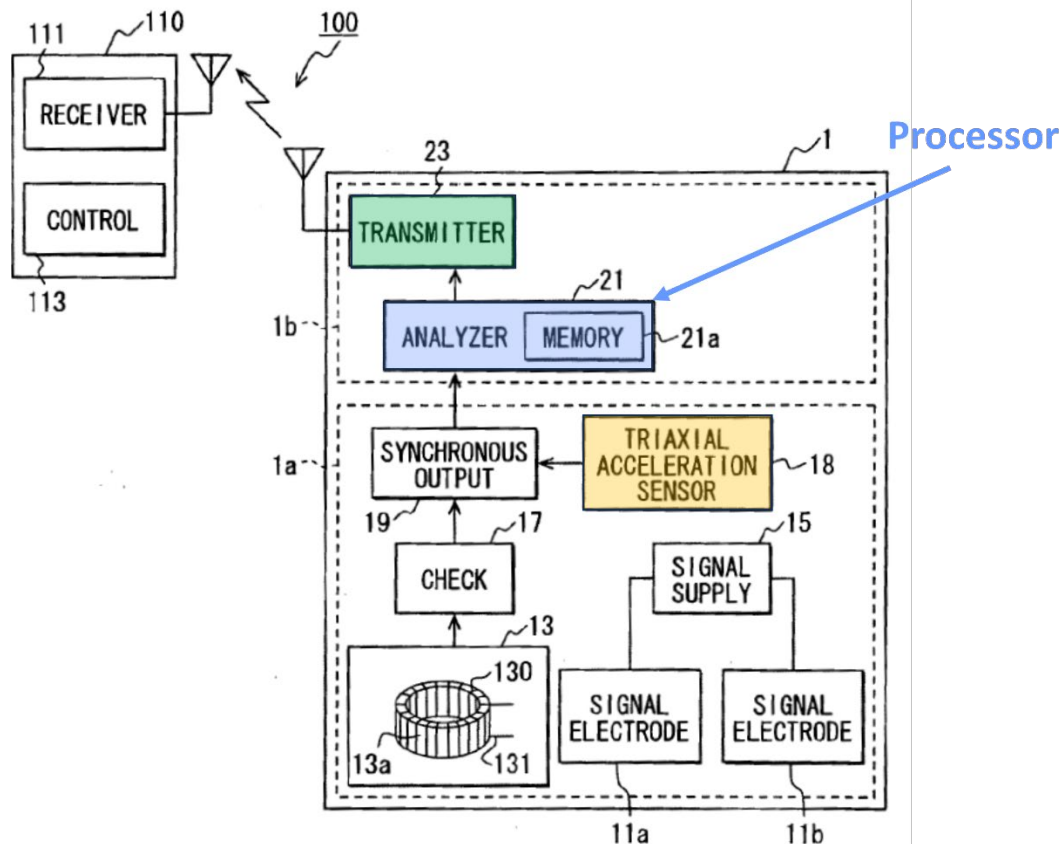
- a. **Element 16[pre(2)]: the wearable computing device comprising at least one sensor module having at least one sensor, at least one processor, and at least one transceiver; the method comprising / Element 30[pre(2)]: including a sensor module having a sensor and a transceiver, which instructions, when executed by the processor, causes the processor to perform operations comprising:**

326. To the extent the preamble is limiting, Asami-Bress teaches Elements

$$16[\text{pre}(2)]/30[\text{pre}(2)].$$

327. Asami's "wearable input device" includes "a triaxial *acceleration sensor* 18...an *analyzer unit* 21 and a *radio transmitter unit* 23." Ex-1014 ¶65, Fig. 6A (annotated below).

FIG. 6A



328. A POSITA would have understood that Asami’s “analyzer 21” is a processor that performs computer operations. Ex-1014 ¶94 (“The analyzer unit 21 [is] configured to execute character recognition and transmission *processing* as shown in FIG. 8.”); *see also id.* Fig. 8.

329. As shown in Figure 6A, Asami's triaxial acceleration sensor is part of

“measurement data output part 1a,” which also includes “current sensor 13.” Ex-1014 ¶¶46, 91, Fig. 6A. A POSITA thus would have understood Asami’s “measurement data output part 1a” to be a sensor module. This measurement data output part, or sensor module, is responsible for collecting various types of data, including acceleration and current measurements, which are then processed by the analyzer unit for accurately interpreting the character gestures.

330. To the extent Asami’s disclosure of “radio transmitter [] 23” (Ex-1014 ¶¶65) not suggest a “transceiver,” Bress teaches a transceiver, including a “WiFi transceiver 406” and a “Bluetooth Transceiver 405.” Ex-1016, 13:65-66, 14:3-5. A POSITA would have been motivated to use a WiFi or Bluetooth transceiver, as taught by Bress, because these are based on well-known, standard protocols for exchange of packet-based data through the use of transceiver electronics hardware.

331. As I explained in the Technology Background section (see Section V), by 2013 wearable electronic devices, including finger rings, having sensors, processors, and transceivers was well-known.

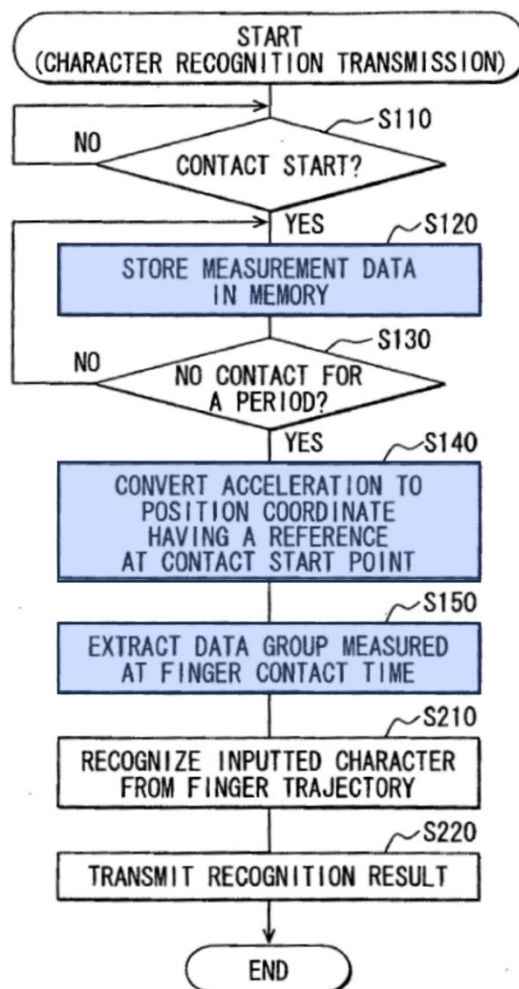
332. A POSITA would have been motivated to combine Asami’s and Bress’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.E.1.

b. Elements 16[a]/30[a]: obtaining, by the sensor of the sensor module, sensor data indicating a motion of the finger or a hand adjointed to the finger wearing the wearable computing device;

333. Asami-Bress teaches Elements 16[a]/30[a].

334. Asami teaches that its “triaxial acceleration sensor 18 is configured to *detect motion of the input finger by detecting acceleration...in the x, y, z axes.*” Ex-1014 ¶73; *see also id.*, Fig. 8 (Steps S120, S140, S150); Fig. 9A (Steps S120, S140, S150).

FIG. 8



335. As I explained in the Technology Background section (see Section V),

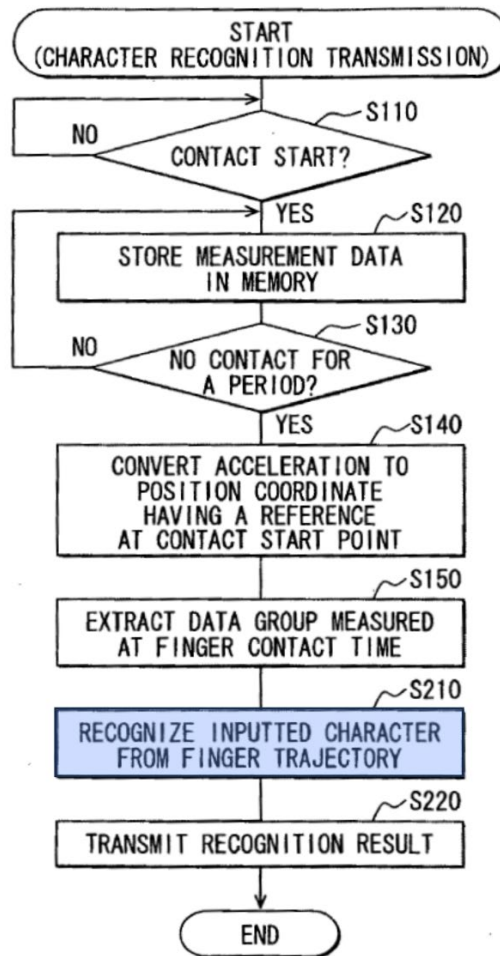
by 2013 the use of motion sensors, such as accelerometers and gyroscopes, in wearable electronic devices, including those with finger ring form factors, was well-known.

c. Elements 16[b]/[30[b]]: comparing, by [one of the at least one] processor[s], the obtained sensor data to a predetermined pattern of motion;

336. Asami-Bress teaches Elements 16[b]/30[b].

337. Asami teaches that its analyzer obtains the triaxial accelerometer data from synchronous output unit 19 (Ex-1014 ¶¶72-73) and compares the obtained data to a predetermined pattern of motion (*id.* ¶75 (trajectory data stored in analyzer memory 21a)). Specifically, in Asami's device, the measured acceleration is "converted into the position coordinate of the input finger of each time." Ex-1014 ¶82. The analyzer then recognizes a character "by *evaluating the degree of agreement between the trajectory pattern of the position coordinate indicated by the measurement data group and a pre-stored trajectory pattern* of a subject character." Ex-1014 ¶96; *see also id.*, Fig. 8 (Step S210), Fig. 9A (Step 310), ¶105. A POSITA would have understood the stored trajectory pattern to be a "predetermined pattern of motion."

FIG. 8



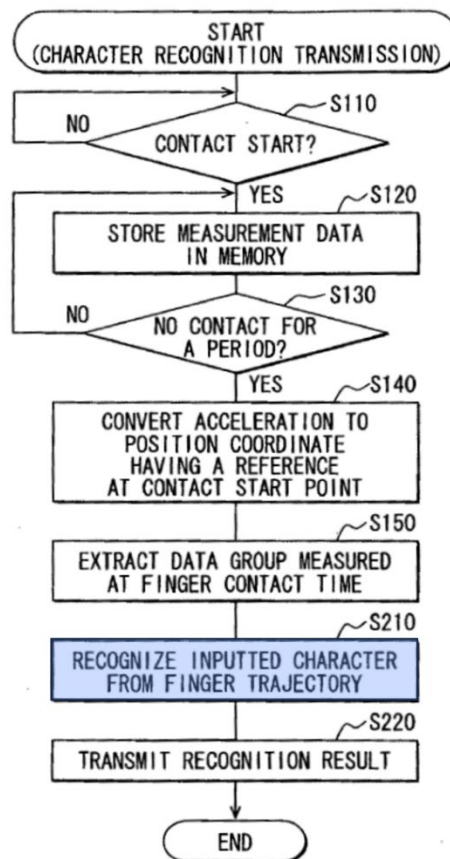
d. Elements 16[c]/[30[c]]: determining, by [one of the at least one] processor[s], whether the obtained sensor data matches a predetermined pattern;

338. Asami-Bress teaches Elements 16[c]/30[c].

339. As explained for the previous element (16[b]/30[b]), Asami teaches that its analyzer determines whether the motion data matches a pre-stored character pattern. Asami states that “[a] character *may be recognized* by evaluating the degree of agreement between the trajectory pattern of the position coordinate indicated by

the measurement data group and a pre-stored trajectory pattern of a subject character.” Ex-1014 ¶96, Fig. 8 (Step 210); *see also id.* ¶99 (the process of determining whether there is a match with the predetermined pattern results in “data representing the recognition result of the character.”); ¶97, Fig. 9A (Step 310), Fig. 9B (showing two predetermined figure patterns), ¶¶105, 107.

FIG. 8



- e. Elements 16[d]/[30[d]]: determining, by [one of the at least one] processor[s], a characteristic of an activity of the user of the wearable computing device when the obtained sensor data matches the predetermined pattern; and

340. Asami-Bress teaches Elements 16[d]/30[d] because Asami teaches them.

341. While the '953 patent specification does not define the term “characteristic of an activity of the user,” the specification states that the wearable computing device “can determine current activity of a user according to measurements taken by one or more sensors in the sensor module, such as accelerometer, gyroscope, magnetometer or digital compass.” Ex-1001, 42:64-67. A POSITA would have understood the plain and ordinary meaning of “characteristic of an activity of the user” to cover any property of the user’s motion or other activity. Asami teaches that the user of its device can be engaged in activities such as “writ[ing] characters or draw[ing] figures (including pictures, symbols, etc.).” Ex-1014 ¶49. Further, Asami’s device allows not only “measuring a trajectory of movement of the input finger,” but also has “a function of detecting contact or separation (non-contact or out-of-contact) of the top end of the input finger to and from the other body part of the user.” Ex-1014 ¶50. Whether the finger is in or out of contact with another body part is determined by the “current sensor 13.” *Id.* ¶¶62. In other words, Asami’s device allows not only recognizing whether the trajectory of the user’s finger in contact with another body part matches a predetermined pattern, but also determining when the finger was in and out of contact and what other motions the user was making when out-of-contact—i.e., the claimed

characteristic(s) of user activity. These activities correspond to the '953 patent specification's description of "current activity of a user according to measurements taken by one or more sensors in the sensor module." Ex-1001, 42:64-66. The ability to detect specific activities, such as writing or drawing, and measure related properties like contact state and motion trajectory, are examples of characteristics that can define a user's activity.

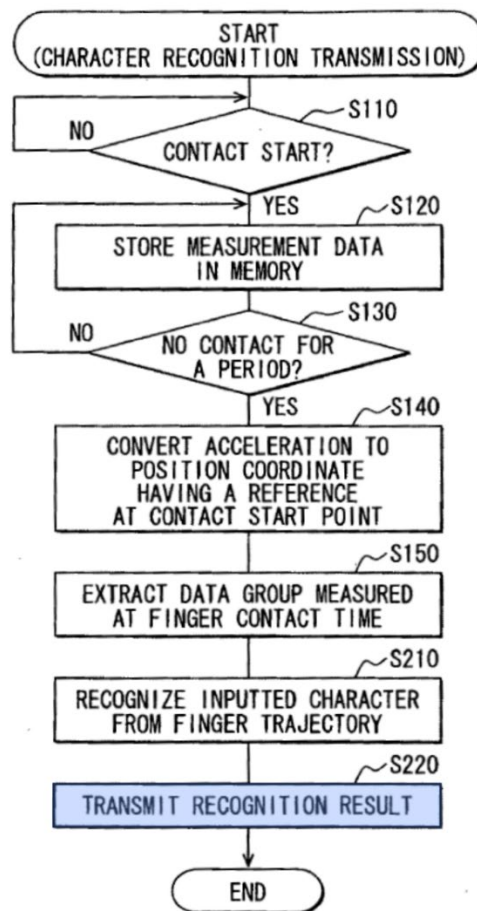
342. Accordingly, a POSITA would also have understood that a characteristic of the user's activity "includes the condition determination value indicating the contact of the input finger, from measurement data group acquired during a period from the start of contact and the continued separation of the input finger." Ex-1014 ¶83. A POSITA would have further understood that a related characteristic of the user's activity is whether the "character or figure [drawn by the user's finger motion] is a combination of a plurality of discontinuous strokes." Ex-1014 ¶90. Another related characteristic of the user's activity determined by the Asami device processor is "the user action corresponding to contacting or separating a pen to or from a paper." Ex-1014 ¶101. A further characteristic of the user's activity is whether the user is "writ[ing] characters or draw[ing] figures." Ex-1014 ¶49. A POSITA would have understood that there are multiple level of characteristics from, for example, the characteristics of simple motion primitives to the characteristics of context and purpose of the user's actions.

f. Elements 16[e]/30[e]: activating the at least one transceiver to transmit a first data packet and/or receive a second data packet in response to a confirmation of the sensor data matching the predetermined pattern.

343. Asami-Bress teaches Elements 16[e]/30[e].

344. Asami teaches that following the character recognition, its device “analyzer unit 21 transmits data indicating the character recognition result to the external device 110 through the radio transmitter unit 23 at S220.” Ex-1014 ¶97, Fig. 8 (Step S220); *see also id.* ¶106, Fig. 9A (Step 320). Asami further teaches that “if the character recognition is not successful, no data may be transmitted to the external device 110.” *Id.* ¶99; *see also id.* ¶108. When character recognition is successful, data representing the recognized character is transmitted to the external device. *Id.* ¶¶99, 106, 108. A POSITA would have recognized from these teachings that Asami teaches activating the transmitter to transmit data in the form of a data packet, containing information, for example, of the ASCII or Unicode value of the character in response to a confirmation that the data matches the pattern.

FIG. 8



345. Bress expressly teaches a transceiver, including a “WiFi transceiver 406” and a “Bluetooth Transceiver 405.” Ex-1016, 13:65-66, 14:3-5. Bress further teaches activating the transceiver to transmit a data packet in response to a confirmation of the sensor data matching the predetermined pattern. A POSITA would have understood that data transmitted under WiFi or Bluetooth protocols is transmitted in data packets. Bress further teaches that “[e]nergy management is critical in wireless devices” and that its device has a low-power or “sleep” mode. Ex-1016, 15:61-64. In the “sleep” mode, “many of the subsystems may be shut

down,” including “[a]ny and all of the communications channels, such as Blue Tooth...and WiFi.” *Id.*, 16:3-7. The processor polls the sensors, including motion sensors and “[s]ensor data during the brief awake times would determine if there is any need to stay awake to verify a change of state, resume sleep, or fully wake up.” *Id.*, 16:8-14. A POSITA would have been motivated to use Bress’s “sleep” mode in Asami’s device to conserve energy and would have understood that the processor could poll motion sensor data in the “sleep” mode and wake up the transceiver to transmit a data packet to the external device, e.g., a command corresponding to a particular gesture, if the sensor data matched a predetermined pattern.

346. As I explained in the Technology Background section (*see* Section V), it was understood by a POSITA in 2013 that electronic components like transceivers consume a significant amount of power. Transceivers, which enable wireless communication, are particularly power-hungry due to their continuous need to send and receive signals. By that time, it was also common knowledge to utilize “sleep” or low-power modes in wearable electronic devices. These modes are designed to reduce power consumption by deactivating or minimizing the activity of power-intensive components when they are not in use. This involved activating their transceivers and other components only when necessary, in order to save energy and minimize the frequency of battery recharging. This approach to power management is crucial in wearable devices, which often have limited battery capacity and are

expected to operate for extended periods between charges. By utilizing sleep modes, these devices can significantly extend their battery life, reducing the frequency of recharging and enhancing user convenience.

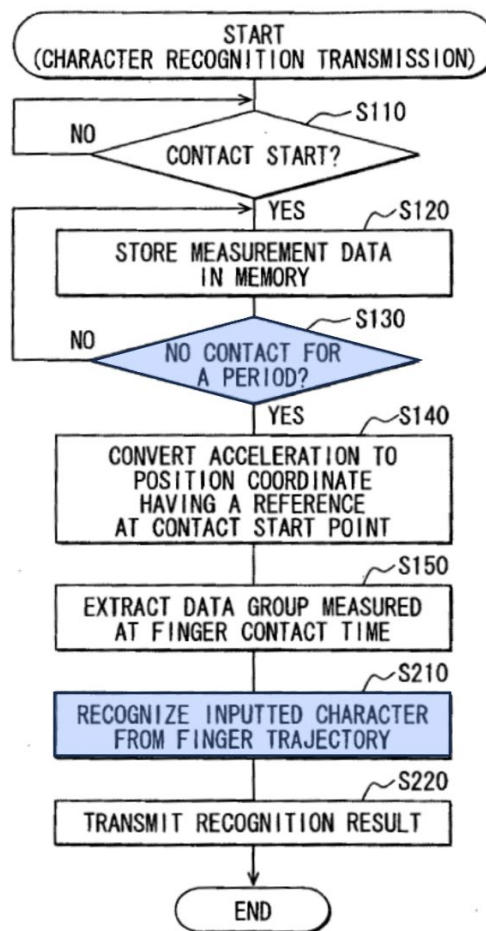
347. A POSITA would have been motivated to combine Asami's and Bress's teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.E.1.

3. **Dependent Claims 17/[31]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: determining that the sensor data matches the predetermined pattern based at least in part on a completion of the activity.**

348. Asami-Bress teaches Claims 17 and 31.

349. Asami's device determines that the sensor data matches the pattern based at least in part on the completion of trajectory of the user's finger. Asami teaches that its analyzer "recognizes at S210 a character, which the user expresses with the input finger, *from the trajectory of the position coordinate* indicated by the extracted measurement data group." Ex-1014 ¶96, Figs. 8, 9A.

FIG. 8



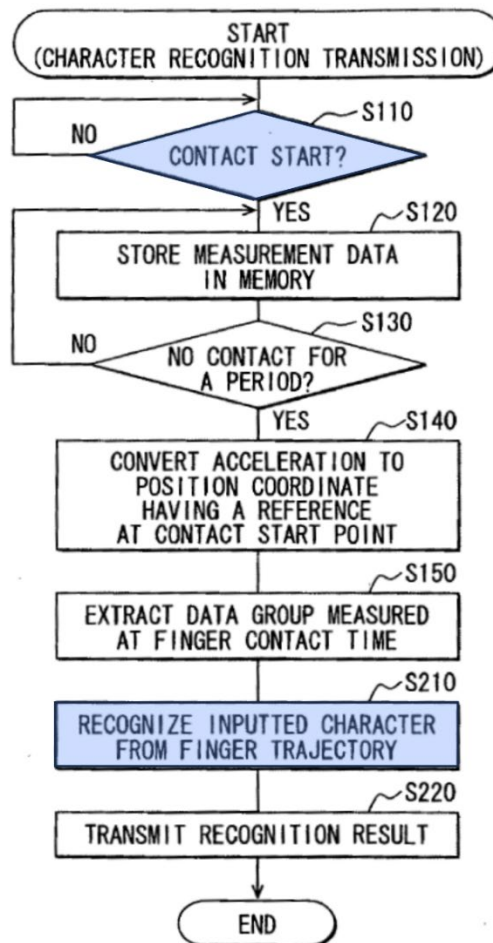
350. As shown in the flowchart in annotated Figure 8 above, Asami's method actively checks at Step 130 whether the user's finger motion has been completed. *Id.*, Fig. 8; *see also id.*, Fig. 7B (showing a completed trajectory of the finger).

4. **Dependent Claims 18/[32]:** The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising:] determining that the sensor data matches the predetermined pattern based at least in part on a start of the activity.

351. Asami-Bress teaches Claims 18 and 32.

352. Asami's device determines that the sensor data matches the pattern based at least in part on the start of the trajectory of the user's finger. Asami teaches that its analyzer "recognizes at S210 a character, which the user expresses with the input finger, *from the trajectory of the position coordinate* indicated by the extracted measurement data group." Ex-1014 ¶96, Figs. 8, 9A.

FIG. 8



353. As shown in the flowchart in annotated Figure 8 above, Asami's

method actively checks at Step 110 whether the user's finger motion has started. *Id.*, Fig. 8. *see also* Ex-1014, Fig. 7B (showing a detected trajectory of the finger, including its start point).

5. Dependent Claim 20: The method of claim 16, wherein the sensor data further comprises an axial rotation measurement.

354. Asami-Bress teaches Claim 20.

355. Bress teaches that the sensor data includes “right and left rotation motion...” Ex-1016, 10:64-65. Bress further teaches that its device includes a “3-axis gyroscope...and [a] 3-axis accelerometer...to generate the motion data.” *Id.*, 14:13-15; Fig. 4 (showing finger-based “3-Axis Gyro” and “3-Axis Accelerometer.”). A POSITA would have understood that a 3-axis gyroscope provides axial rotation measurements.

356. As I explained in the Technology Background section (*see* Section V), gyroscopes and their use in wearable electronic devices were well-known by 2013, and gyroscopes were often used in conjunction with accelerometers for additional versatility in detecting various motions, in particular for gesture recognition. For example, Mestas teaches that in its athletic monitoring device “[p]hysical gestures and movements may be detected using an accelerometer, a gyroscope and/or other sensors.” Ex-1010 ¶221 (Mestas). Sun teaches that “representative MEMS [microelectromechanical systems]” sensors for its gesture-based wrist/finger mouse

include, besides accelerometers, “gyroscopes, including capacitive or piezoelectric vibrating gyroscopes.” Ex-1015 ¶25 (Sun). The publication by Amma in 2010 also teaches the use of “gyroscopes for measuring angular velocity” in wearable input devices. Ex-1068, 2 (Amma). Similarly, Park noted in 2011 that “[r]ecently, hand-worn accelerometer and gyroscope sensor-based gesture recognition has been successfully used in mobile and pervasive computing. This approach is appealing because it is low cost, low power, requires only lightweight processing, and can be implemented with compact form factors. Several projects have proposed gesture recognition systems based on a wide range of sensing form factors.” Ex-1070, 262 (Park). Park further explains that “while the accelerometer is often used in gesture recognition systems...recent research demonstrates that additional use of a gyroscope can improve gesture classification accuracy...by up to 4% because it can detect rotational movements.” *Id.*, 263.

357. A POSITA would have been motivated to combine Asami’s and Bress’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.E.1.

6. **Dependent Claims 21/[33]: The method of claim 16/[The non-transitory computer readable storage medium of claim 30], wherein the [at least one] sensor module comprises one or more of a light sensor, a gyroscope, and/or a magnetometer, and the sensor data further comprises a measurement from one or more of the light sensor, a gyroscope, and/or a magnetometer.**

358. Asami-Bress teaches Claims 21 and 33.

359. Bress teaches that its device includes a “**3-axis gyroscope**...and [a] 3-axis accelerometer...to generate the motion data.” Ex-1016, 14:13-15; Fig. 4 (showing finger-based “**3-Axis Gyro**” and “3-Axis Accelerometer.”).

360. As I explained in the Technology Background section (*see* Section V), by 2013 gyroscopes were often used in conjunction with accelerometers for additional versatility in detecting various motions, in particular for gesture recognition. For example, Mestas teaches that in its athletic monitoring device “[p]hysical gestures and movements may be detected using an accelerometer, a gyroscope and/or other sensors.” Ex-1010 ¶221 (Mestas). Sun teaches that “representative MEMS [microelectromechanical systems]” sensors for its gesture-based wrist/finger mouse include, besides accelerometers, “gyroscopes, including capacitive or piezoelectric vibrating gyroscopes.” Ex-1015 ¶25 (Sun). The publication by Amma in 2010 also teaches the use of “gyroscopes for measuring angular velocity” in wearable input devices. Ex-1068, 2 (Amma). Similarly, Park noted in 2011 that “[r]ecently, hand-worn accelerometer and gyroscope sensor-based gesture recognition has been successfully used in mobile and pervasive computing. This approach is appealing because it is low cost, low power, requires only lightweight processing, and can be implemented with compact form factors. Several projects have proposed gesture recognition systems based on a wide range of sensing

form factors.” Ex-1070, 262 (Park). Park further explains that “while the accelerometer is often used in gesture recognition systems...recent research demonstrates that additional use of a gyroscope can improve gesture classification accuracy...by up to 4% because it can detect rotational movements.” *Id.*, 263.

361. As I also explained in the Technology Background section (*see* Section V), the use of magnetometers for motion sensing and gesture recognition was well-known by 2013. For example, Amma described that by 2010 “the technology of sensors is advancing significantly, allowing for very small, body-worn, wearable sensors...suitable for intuitive wearable computing systems. Traditionally used sensors, which are small and come at very reasonable costs are accelerometers, gyroscopes and magnetometers.” Ex-1068 at 1 (Amma).

362. A POSITA would have been motivated to combine Asami’s and Bress’s teachings and would have had a reasonable expectation of success for the reasons discussed in §VIII.E.1.

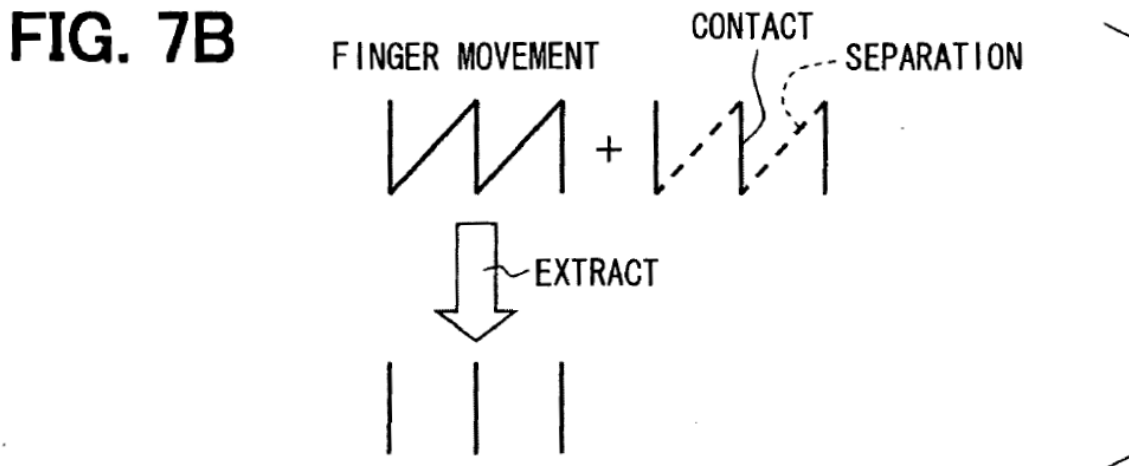
7. Dependent Claims 23 and 34

a. Elements 23[pre/a]/[34[pre/a]]: The method of claim 16, further comprising/[The non-transitory computer readable storage medium of claim 30, wherein the processor further executes an operation comprising]: converting the sensor data into a series of samples;

363. Asami-Bress teaches Elements 23[pre/a]/34[pre/a].

364. Asami teaches at “[a]t S140, the analyzer unit 21 converts the

acceleration measurement values indicated by a *series of measurement data* stored in the memory 21a into a position coordinate having a reference (point of origin) at a position.” Ex-1014 ¶81. Asami further describes an “extraction operation” that outputs “at S150, the measurement data group indicating the position coordinate of the input finger while the input finger is in contact with the other body part.” *Id.* ¶84, Fig. 7B, reproduced below (showing “at the bottom left part” a series of samples following the extraction).



365. Further, in Asami method, “a *time-sequence data of the position coordinate* indicated by each measurement data is generated.” *Id.* ¶85. A POSITA would have understood these disclosures to teach converting the sensor data into a series of samples.

b. Elements 23[b]/34[b]: comparing the series of samples to the predetermined pattern; and

366. Asami-Bress teaches Elements 23[b]/34[b].

367. Asami teaches that the series of samples obtained from the extraction at the previous step are compared to a pre-stored pattern. Ex-1014 ¶96 (“A character may be recognized by evaluating the degree of agreement between the *trajectory pattern of the position coordinate indicated by the measurement data group* and a pre-stored trajectory pattern of a subject character.”).

c. Elements 23[c]/34[c]: determining that the sensor data matches the predetermined pattern if the series of samples matches the predetermined pattern.

368. Asami-Bress teaches Elements 23[c]/34[c].

369. Asami teaches that with its method a character or a figure is recognized if the series of samples matches the pre-stored pattern. Ex-1014 ¶96 (“A character may be recognized by evaluating the degree of agreement between the *trajectory pattern of the position coordinate indicated by the measurement data group* and a pre-stored trajectory pattern of a subject character.”).

8. Dependent Claims 24 and 35: The method of claim 23, wherein/[The non-transitory computer readable storage medium of claim 34, wherein the processor further executes an operation comprising:] the comparing between the series of samples and the predetermined pattern is determined by a recognition technique.

370. Asami teaches-Bress Claims 24 and 35.

371. Asami teaches that the analyzer unit 21 may be configured to execute character recognition, i.e., performing a recognition technique. Ex-1014 ¶94 (“The analyzer unit 21 may be configured to *execute character recognition*.”); ¶96 (“A

character may be recognized by evaluating the degree of agreement between the *trajectory pattern of the position coordinate indicated by the measurement data group* and a pre-stored trajectory pattern of a subject character.”).

372. As I explained in the Technology Background section (Section §V), recognition techniques were well-known by 2013, and virtually any gesture recognition application would have applied a recognition technique, where it be a simple template-matching/correlation or more complex techniques such as machine learning. By 2013, a range of pattern recognition methods were known. These methods ranged from simple template-matching and correlation techniques to more complex machine learning algorithms. Template-matching involves comparing input data to a set of predefined templates or patterns to find the closest match. This technique is straightforward and effective for recognizing predefined gestures or shapes. More advanced techniques, such as machine learning, involve training algorithms on large datasets to recognize and differentiate between various patterns or gestures. Machine learning models, such as neural networks, can learn from data and improve their recognition accuracy over time.

IX. CONCLUSION

373. For the reasons set forth above, it is my opinion that Claims 16-18, 20-21, 23-24, 30-35, and 37 of the '953 Patent are unpatentable in view of the prior art.

374. 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 if cross-examination is required of me, I will appear for cross-examination during the time allotted for cross-examination.

375. 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.

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

U.S. Patent No. 10,281,953
Declaration of Brian W. Anthony, Ph.D.

Dated: June 28, 2024

Respectfully submitted,

A handwritten signature in blue ink, appearing to read 'Brian W. Anthony', is written over a horizontal line.

Brian W. Anthony, Ph.D.