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Paper 22
Date: August 3, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

OMNI MEDSCI, INC.,
Patent Owner.

IPR2021-00453
Patent 10,517,484 B2

Before GRACE KARAFFA OBERMANN, BRIAN J. McNAMARA, and SHARON FENICK, *Administrative Patent Judges.*

McNAMARA, *Administrative Patent Judge*.

JUDGMENT
Final Written Decision
Determining Some Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. BACKGROUND

On August 6, 2021 we instituted an *inter partes* review of claims 1–23 of U. S. Patent No. 10,517,484 B2 ("the '484 Patent"). Paper 7 ("Dec. to Inst."). Omni MedSci, Inc. ("Patent Owner') filed a Patent Owner Response (Paper 10, "PO Resp."), Apple, Inc. ("Petitioner") filed a Petitioner Reply (Paper 11, "Pet. Reply") and Patent Owner filed a Sur-reply (Paper 13, "PO Sur-reply"). A transcript of an oral hearing held on May 5, 2022 (Paper 20, "Hr'g. Tr.") has been entered into the record.

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision is issued pursuant to 35 U.S.C. § 318(a). We base our decision on the preponderance of the evidence. 35 U.S.C. § 316(e); 37 C.F.R. § 42.1(d).

Having reviewed the arguments of the parties and the supporting evidence, we conclude that Petitioner has demonstrated by a preponderance of the evidence that challenged claims 1, 2, 7, and 15–23 are unpatentable and that Petitioner has not demonstrated challenged claims 3–6 and 8–14 to be unpatentable.

II. THE '484 PATENT

The '484 patent concerns a device that can be placed on a user's ear or wrist to measure a physiological parameter. Ex. 1001 (code 57). A plurality of light emitting diodes generate light at an initial intensity and a receiver with spatially placed detectors receiving reflected light provides analog signals to an analog-to-digital converter ("A/D"). *Id.* Signal-to-noise ratio is improved by increasing light intensity relative to initial light intensity and increasing a pulse rate. *Id.* The system inspects a sample "by comparing different features, such as wavelength (or frequency), spatial location, transmission, absorption, reflectivity, scattering, refractive index, or opacity" of the sample. *Id.* at 10:2–7.

Figure 24 of the '484 patent is reproduced below.

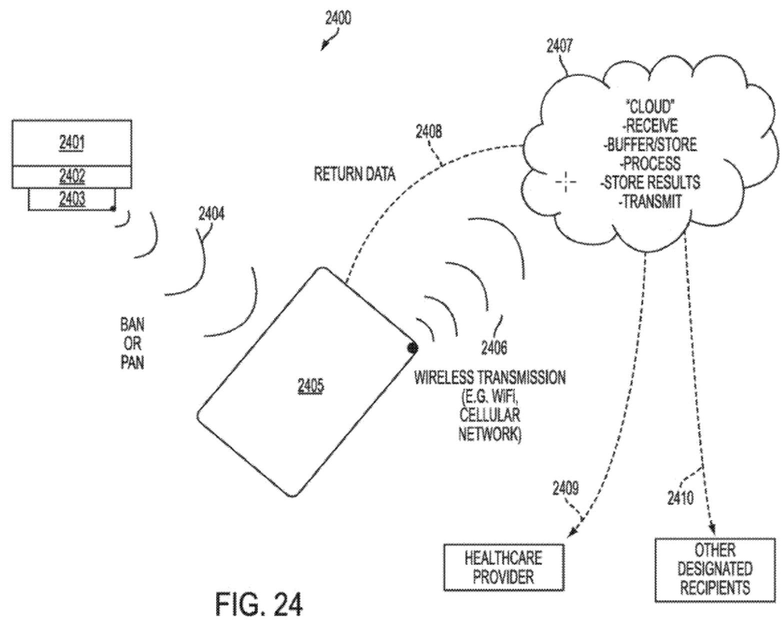

FIG. 24

Figure 24 of the '484 patent

Figure 24 is a high level overview of physiological measurement system 2400, in which wearable measurement device 2401 with processor 2402 and transmitter 2403 communicates measurements over link 2404 to smart phone or tablet 2405. *Id.* at 32:45–33:4. An application program in smart phone or tablet 2405 communicates some or all of its processed data over link 2406 to cloud based server 2407, which can augment the data with additional value-added processing, e.g., historical processing and pattern matching algorithms. *See id.* at 33:5–34:21.

The wearable device includes a light source having a plurality of LEDs, electronically driven to operate in a continuous or pulsed mode, that generate an output beam at one or more optical wavelengths between 700 and 2500 nanometers. Ex. 1001, 3:34–49, 11:3–9, 28:19–21, 26:29–34, Fig. 20. The '484 patent describes several techniques to improve signal processing to select the constituents of interest. *See, e.g., id.* at 15:49–17:15. According to the '484 patent, "using a wider wavelength range and using more sampling wavelengths may improve the ability to discriminate one signal from another." *Id.* at 15:64–66. In addition, "a higher light level or intensity may improve the signal-to-noise ratio for the measurement." *Id.* at 15:53–55. The '484 patent notes that

> it may be advantageous to pulse the light source with a particular pulse width and pulse repetition rate, and then the detection system can measure the pulsed light returned from or transmitted through the tissue. Using a lock-in type technique (e.g., detecting at the same frequency as the pulsed light source and also possibly phase locked to the same signal), the detection system may be able to reject background or spurious signals and increase the signal-to-noise ratio of the measurement.

Id. at 15:67–16:8. The '484 patent further explains that variations due to sunlight, time of day, and weather may also be reduced to improve the signal-to-noise ratio using a lock-in technique. *Id.* at 16:61–67.

> Higher signal-to-noise ratios may be achieved. For example, one way to improve the signal-to-noise ratio would be to use modulation and lock-in techniques. In one embodiment, the light source may be modulated, and then the detection system would be synchronized with the light source. In a particular embodiment, the techniques from lock-in detection may be used, where narrow band filtering around the modulation frequency may be used to reject noise outside the modulation, frequency. In an alternate embodiment, change detection schemes may be used, where the detection system captures the signal with the light source on and with the light source off. Again, for this system the light source may be modulated. Then, the signal with and without the light source is differenced. This may enable the sun light changes to be subtracted out. In addition, change detection may help to identify objects that change in the field of view.

Id. at 16:64–17:13. Patent Owner also notes that the '484 patent incorporates by reference PCT Application Serial No. PCT/US2013/075767 (Publication No. WO/2014/143276) (Ex. 2120), which describes the use of an active illuminator to achieve higher signal-to-noise ratios despite variations due to sunlight and weather, and U.S. Patent Application Serial No. 14/109,007, which discloses the modulation frequency of the light source can range between 0.1–100 kHz. *See* Paper 6, Preliminary Response 5 (citing Ex. 1001, 2:26–29, 2:36–39; Ex. 2120 ¶ 79; Ex. 2021 ¶ 45).

III. ILLUSTRATIVE CLAIM

Claim 1, reproduced below using the paragraph designations in the Petition, is illustrative of the subject matter of the challenged claims.

> 1(a). A system for measuring one or more physiological parameters and for use with a smart phone or tablet, the system comprising:
>
> (b) a wearable device adapted to be placed on a wrist or an ear of a user,
>
> (c) including a light source comprising a plurality of semiconductor sources that are light emitting diodes, each of the light emitting diodes configured to generate an output optical light having one or more optical wavelengths;
>
> (d) the wearable device comprising one or more lenses configured to receive a portion of at least one of the output optical lights and to direct a lens output light to tissue;
>
> (e) the wearable device further comprising a detection system configured to receive at least a portion of the lens output light reflected from the tissue and to generate an output signal having a signal-to-noise ratio,
>
> (f) wherein the detection system is configured to be synchronized to the light source;
>
> (g) wherein the detection system comprises a plurality of spatially separated detectors, and wherein at least one analog to digital converter is coupled to at least one of the spatially separated detectors;
>
> (h) wherein a detector output from the at least one of the plurality of spatially separated detectors is coupled to an amplifier having a gain configured to improve detection sensitivity;
>
> (i) the smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, a voice input module, one or more buttons or knobs, a microprocessor and

a touch screen, the smart phone or tablet configured to receive and process at least a portion of the output signal, wherein the smart phone or tablet is configured to store and display the processed output signal, and wherein at least a portion of the processed output signal is configured to be transmitted over a wireless transmission link;

(j) a cloud configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data, and to store the processed data;

(k) wherein the output signal is indicative of one or more of the physiological parameters, and the cloud is configured to store a history of at least a portion of the one or more physiological parameters over a specified period of time;

(l) the wearable device configured to increase the signal-to-noise ratio

(1) by increasing light intensity of at least one of the plurality of semiconductor sources from an initial light intensity and

(2) by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial pulse rate; and

(m) the detection system further configured to:
generate a first signal responsive to light received while the light emitting diodes are off,

(n) generate a second signal responsive to light received while at least one of the light emitting diodes is on, and

(o) increase the signal-to-noise ratio by comparing the first signal and the second signal.

IV. GROUNDS OF INSTITUTION

We instituted *inter partes* on all grounds asserted in the Petition, as shown in the following table:

Claim(s) Challenged	35 U.S.C. §	Reference(s)
1, 7, 15, 17	103	Lisogurski,[1] Carlson[2]

[1] U.S. Patent No. 9,241,676 (Ex. 1011).
[2] U.S. Patent Publication No. 2005/0049468 (Ex. 1009).

Claim(s) Challenged	35 U.S.C. §	Reference(s)
1–4, 7–12, 15–22	103	Lisogurski, Carlson, Tran[3]
5, 13	103	Lisogurski, Carlson, Tran, Isaacson[4]
6, 14, 23	103	Lisogurski, Carlson, Tran, Valencell-093,[5] with or without Isaacson

V. CLAIM CONSTRUCTION

As the Patent Owner Response proposes constructions for terms not previously construed (PO Resp. 8–14), we review the parties' claim construction proposals provided throughout this proceeding.

A. The Pulse Rate Limitation

The Petition proposed claim constructions for the following terms: lens, optical light, light source . . . configured to increase signal-to-noise ratio by . . . increasing a pulse rate of at least one of the plurality of semiconductor devices ("the pulse rate limitation"[6]), and cloud. Pet. 19–21. Patent Owner does not propose constructions for these terms. PO Resp. 8–10. As to the pulse rate limitation, Petitioner directs us to a related case, *Apple Inc. v. Omni MedSci, Inc,* IPR2019-00916 ("the '916 IPR"), that concerned U.S. Patent No. 9,651,533 ("the '533 patent"). Pet. 19. In the 916 IPR, the panel construed a similar limitation to mean "a light source containing two or more light emitting diodes (semiconductor sources), wherein at least one of the light emitting diodes is capable of having its pulse rate increased to increase a signal-to-noise ratio." Pet. 21. Petitioner

[3] U.S. Patent No. 8,108,036 (Ex. 1064).
[4] U.S. Patent No. 8,725,226 (Ex. 1063).
[5] U.S. Patent Publication No. 2012/0197093 (Ex. 1005).
[6] Patent Owner first identified this limitation as the Pulse Rate Limitation in the Preliminary Response. Prelim. Resp. 8.

states that it supports this construction, but that it "does not believe this term requires construction because the prior art teaches it even under the construction [Patent Owner] proffered in IPR2019-00916." *Id.* In the Decision to Institute, we determined that no claim construction was required. Dec. to Inst. 8–10. The Patent Owner Response contends that the pulse rate limitation needs no construction (PO Resp. 8–11) and, having reviewed the entire record, we agree that no claim construction is needed for the pulse rate limitation.

B. "to identify an object" (claims 3 and 8) and "to detect an object" (claim 16)

Patent Owner notes that claims 3 and 8 recite that "the wearable device is configured . . . to identify an object [,]" as distinguished from claim 16, which recites that "the wearable device is configured . . . to detect an object." PO Resp. 11–14. Patent Owner proposes that we construe the expression "to identify an object," as used in claims 3 and 8 to mean "to recognize or establish an object as being a particular thing." PO Resp. 13. Patent Owner proposes that we construe the term "to detect an object" to mean "to discover or notice the existence or presence of something." *Id.* 14. Patent Owner cites dictionary definitions defining "identify" to mean "to recognize or establish as being a particular person or thing" (*id.* at 11) and "detect" to mean "to discover or notice the existence or presence of" (*id.* at 13). Patent Owner contends that "the difference in claim language creates a presumption that ***identification*** which requires recognizing or establish an object is a particular thing differs from ***detection***, which merely requires noticing an object's presence." *Id.* at 12.

Petitioner states that "to the extent a construction of the term 'detect an object is needed, a skilled person would understand it to mean 'to discover or determine the existence, presence, or fact of an object.'" Pet. Reply 19–20. Petitioner acknowledges that its proposed construction of "detect an object" is "generally consistent with [Patent Owner]'s proposed construction" but contends its construction is "more appropriate for system claims, given that a system can 'discover' or determine but not 'notice' something." *Id.* at 20.

Petitioner contends that in the context of the '484 patent, we should consider the expressions "identify an object" and "detect an object" to have the same meaning, i.e., "to discover or determine the existence, presence, or fact of an object." Pet. Reply 20. According to Petitioner, notwithstanding the difference in the claim language, "identify" is used in the claims and the specification "simply to confirm that an object is present or not, rather than to take any action dependent on what the object is," i.e., "the claims do not require the device to take any actions based on what an object is—they only require determining if something physical (an object) is present." *Id.* at 20–21. Petitioner also states that many of Patent Owner's citations to the '484 patent Specification in support of Patent Owner's proposed construction are irrelevant to the claims because they involve actions not recited in the claims. *Id.* at 21.

Petitioner's argument that Patent Owner's citations to the Specification concerning the terms "identify" and "detect" involve actions not recited in the claims does not change the fact that these different claim terms are presumed to have different meanings. The dictionary definitions of "detect" and "identify" are different. The use of the term "identify" in claims 3 and 8 and the use of a different term, i.e., "detect," in claim 16 indicates that the claims 3 and 8 mean something different from claim 16. Petitioner has not rebutted the presumption that different claim terms have different meanings, whether or not these citations relate to unclaimed subject matter. *See SimpleAir, Inc. v. Sony Ericsson Mobile Commc'ns AB*, 820 F.3d 419, 431 (Fed. Cir. 2016).

Therefore, we decline to adopt Petitioner's proposal to construe the terms "identify an object" and "detect an object" to have the same meaning. Instead, we construe these terms consistent with the dictionary definitions of "identify" and "detect," i.e., we construe "to identify an object" to mean "to recognize or establish an object as being a particular thing," and we construe "to detect an object" to mean "to discover or notice the existence or presence of something." We address the specific implications of these constructions in our discussion of claims 3, 8, and 16.

VI. ANALYSIS OF PRIOR ART CHALLENGES

A. Introduction

"In an [inter partes review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")). This burden of persuasion never shifts to Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (discussing the burden of proof in *inter partes* review).

The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art;

(3) the level of ordinary skill in the art[7]; and (4) objective evidence of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

Additionally, the obviousness inquiry typically requires an analysis of "whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007) (citing *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (requiring "articulated reasoning with some rational underpinning to support the legal conclusion of obviousness")); *see In re Warsaw Orthopedic, Inc.*, 832 F.3d 1327, 1333 (Fed. Cir. 2016) (citing *DyStar Textilfarben GmbH & Co. Deutschland KG v. C. H. Patrick Co.*, 464 F.3d 1356, 1360 (Fed. Cir. 2006)).

An obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 550 U.S. at 418; *accord In re Translogic Tech., Inc.*, 504 F.3d 1249, 1259 (Fed. Cir. 2007). Petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016). Instead, Petitioner must articulate a reason why a person of ordinary skill in the art would have combined the prior art references. *In re NuVasive*, 842 F.3d 1376, 1382 (Fed. Cir. 2016).

A reason to combine or modify the prior art may be found explicitly or implicitly in "market forces; design incentives; the 'interrelated teachings of multiple patents'; 'any need or problem known in the field of endeavor at

[7] The level of ordinary skill in this case is discussed in the Decision to Institute and is uncontested. Dec. to Inst. 7–8.

the time of invention and addressed by the patent'; and the background knowledge, creativity, and common sense of the person of ordinary skill." *Perfect Web Techs., Inc. v. InfoUSA, Inc.*, 587 F.3d 1324, 1328–29 (Fed. Cir. 2009) (quoting *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 418–21 (2007)).

As part of determining whether a claim is obvious in light of the prior art, we consider any relevant evidence of secondary considerations of non-obviousness. *See Graham*, 383 U.S. at 17. Notwithstanding what the teachings of the prior art would have suggested to one of ordinary skill in the art at the time of the invention, the totality of the evidence submitted, including objective evidence of non-obviousness, may lead to a conclusion that the challenged claims would not have been obvious to one of ordinary skill. *In re Piasecki*, 745 F.2d 1468, 1471–72 (Fed. Cir. 1984). No such evidence is before us.

B. Claims 1, 7, 15, 17 As Obvious Over Lisogurski and Carlson

Petitioner states that claims 1, 7, and 15 contain overlapping limitations with identical or similar language. Pet. 38 n.7. Arguing that the distinctions between independent claims 1, 7, and 15 are inconsequential to patentability as variations that would be obvious to one of ordinary skill in the art, the Petition addresses these claims together and notes any difference at the start of its discussion of each limitation. *Id.* at 26–27. As discussed below, much of the dispute concerns claim limitation 1(l)(2), the "pulse rate limitation." Patent Owner does not contest Petitioner's contentions that the remaining claim limitations obvious over the cited prior art. *See generally* PO Resp. Having reviewed the claims and the evidence of record, we agree with Petitioner that variations in language of claim 1, 7, and 15 are inconsequential to patentability and treat claim 1 as exemplary. We also note that claim 15 does not recite the pulse rate limitation.

1. Lisogurski

Lisogurski discloses a "physiological monitoring system [that] monitor[s] one or more physiological parameters of a patient . . . using one or more physiological sensors." Ex. 1011, 3:44–46. The physiological sensors may include a "pulse oximeter [that] non-invasively measure[s] the oxygen saturation of a patient's blood." *Id.* at 3:62–64. The pulse oximeter includes "a light sensor that is placed at a site on a patient, typically a fingertip, toe, forehead, or earlobe." *Id.* at 4:6–7. The light sensor "pass[es] light through blood perfused tissue and photoelectrically sense[s] the absorption of the light in the tissue." *Id.* at 4:8–10. The light sensor emits "one or more wavelengths [of light] that are attenuated by the blood in an amount representative of the blood constituent concentration," and may include red and infrared (IR) wavelengths of light. *Id*. at 4:42–48. Figure 3 of Lisogurski is reproduced below.

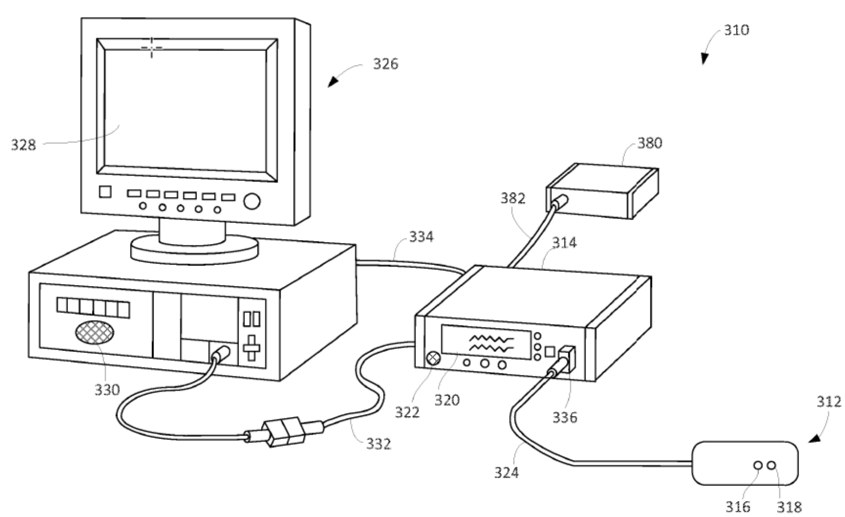

FIG. 3

Figure 3 of Lisogurski is "a perspective view of an embodiment of a physiological monitoring system." *Id*. at 2:23–25. The system includes sensor 312, monitor 314, and multi-parameter physiological monitor 326. *Id*. at 17:35–36, 18:44–45. Sensor 312 includes "one or more light source[s] 316 for emitting light at one or more wavelengths," and detector 318 for "detecting the light that is reflected by or has traveled through the subject's tissue." *Id*. at 17:37–42. Sensor 312 may have "[a]ny suitable configuration of light source 316 and detector 318," and "may include multiple light sources and detectors [that] may be spaced apart." *Id*. at 17:42–45. Light source 316 may include "LEDs of multiple wavelengths, for example, a red LED and an IR [LED]." *Id*. at 19:25–27. Sensor 312 may be "wirelessly connected to monitor 314." *Id*. at 17:57–59.

Monitor 314 "calculate[s] physiological parameters based at least in part on data relating to light emission . . . received from one or more sensor units such as sensor unit 312." *Id*. at 17:59–62. Monitor 314 includes "display 320 . . . to display the physiological parameters," and "speaker 322 to provide an audible . . . alarm in the event that a subject's physiological parameters are not within a predefined normal range." *Id*. at 18:3–10. Monitor 314 is "communicatively coupled to multi-parameter physiological monitor 326" ("MPPM 326") and "may communicate wirelessly" with MPPM 326. *Id*. at 18:58–61. Monitor 314 may also be "coupled to a network to enable the sharing of information with servers or other workstations." *Id*. at 18:62–65. Multi-parameter physiological monitor 326 may also "calculate physiological parameters and . . . provide a display 328 for information from monitor 314." *Id*. at 18:49–52. MPPM 326 may also be "coupled to a network to enable the sharing of information with servers or other workstations." *Id*. at 18:62–65. The remote network servers may also "be used to determine physiological parameters," and may display the parameters on a remote display, display 320 of monitor 314, or display 328 of MPPM 326. *Id*. at 20:53–58. The remote servers may also "publish the data to a server or website," or otherwise "make the parameters available to a user." *Id*. at 20:58–60. Lisogurski discloses that the monitoring system shown in Figure 3, described above, "may include one or more components of physiological monitoring system 100 of FIG. 1." *Id*. at 17:32–35. Lisogurski further discloses that although "the components of physiological monitoring system 100 . . . are shown and described as separate components . . . . the functionality of some of the components may be combined in a single component," and "the functionality of some of the components . . . may be divided over multiple components." *Id*. at 15:66–16:8. Figure 1 of Lisogurski is reproduced below.

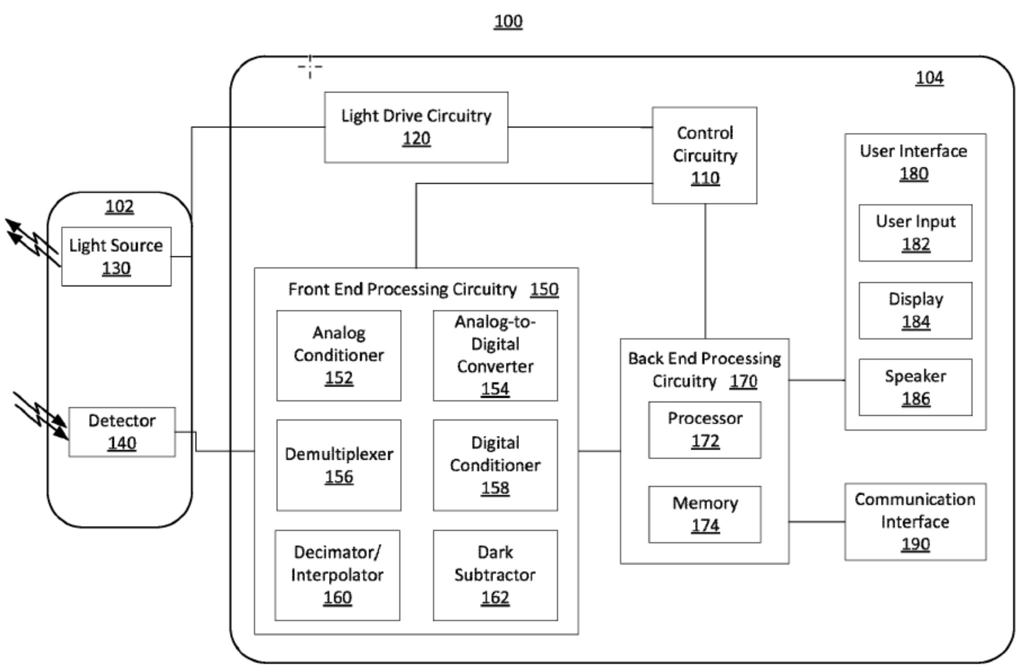

FIG. 1

Figure 1 of Lisogurski

Figure 1 of Lisogurski is a "block diagram of an illustrative physiological monitoring system." Ex. 1011, 2:11–13. The system includes "sensor 102 and a monitor 104 for generating and processing physiological signals of a subject." *Id*. at 10:44–46. Sensor 102 includes "light source 130 and detector 140." *Id*. at 10:48–49. Light source 130 includes "a Red light emitting light source and an IR light emitting light source," such as Red and IR emitting LEDs, with the IR LED emitting light with a "wavelength may be between about 800 nm and about 1000 nm." *Id*. at 10:52–58. Detector 140 "detect[s] the intensity of light at the Red and IR wavelengths," converts them to an electrical signal, and "send[s] the detection signal to monitor 104, where the detection signal may be processed and physiological parameters may be determined." *Id*. at 11:9–10, 11:20–23. Monitor 104 includes user interface 180, communication interface 190, and control circuitry 110 for controlling (a) light drive circuitry 120, (b) front end processing circuitry 150, and (c) back end processing circuitry 170 via "timing control signals." *Id*. at 11:33–38, Fig. 1. Light drive circuitry 120 "generate[s] a light drive signal . . . used to turn on and off the light source 130, based on the timing control signals." *Id*. at 11:38–40. The light drive signal "control[s] the intensity of light source 130 and the timing of when [the] light source 130 is turned on and off." *Id*. at 11:50–54. Front end processing circuitry 150 "receive[s] a detection signal from detector 140 and provide[s] one or more processed signals to back end processing circuitry 170." *Id*. at 12:42–45. Front end processing circuitry 150 also "synchronize[s] the operation of an analog-to-digital converter and a demultiplexer with the light drive signal based on the timing control signals." *Id*. at 11:43–46.

Back end processing circuitry 170 "use[s] the timing control signals to coordinate its operation with front end processing circuitry 150." *Id*. at 11:46–49. Back end processing circuitry 170 includes processor 172 and memory 174, and "receive[s] and process[es] physiological signals received from front end processing circuitry 150" in order to "determine one or more physiological parameters." Ex. 1011, 14:56–57, 14:60–64. Back end processing circuitry 170 is "communicatively coupled [to] user interface 180 and communication interface 190." *Id*. at 15:16–18. User interface 180 includes "user input 182, display 184, and speaker 186," and may include "a keyboard, a mouse, a touch screen, buttons, switches, [and] a microphone." *Id*. at 15:19–22. Communication interface 190 allows "monitor 104 to exchange information with external devices," and includes transmitters and receivers to allow wireless communications. *Id*. at 15:43–44, 15:48–57. Lisogurski teaches the physiological monitoring system may modulate the light drive signal to have a "period the same as or closely related to the period of [a] cardiac cycle." Ex. 1011, 25:49–51. Thus, "[t]he system may vary parameters related to the light drive signal including drive current or light brightness, duty cycle, firing rate, . . . [and] other suitable parameters." *Id*. at 25:52–55.

Lisogurski discloses that a system may use various cardiac cycle modulation techniques to adjust the brightness of a light source controlled by the light drive signal, e.g., using a sinusoid or triangle wave whose period is related to cardiac pulse rate. *Id.* at 6:31–41. In addition, to improve the quality of the physiological parameter determination, cardiac cycle modulation may align the period of the modulated light drive signal with a particular point in the cardiac cycle, e.g., the diastolic period, the systolic period, the dicrotic notch, or any other suitable point. *Id.* at 6:41–46. The cardiac cycle modulation may also be based on empirical data concerning the determined physiological parameter. *See id.* at 6:53–7:3.

Lisogurski also describes combining cardiac cycle modulation with drive cycle modulation. Ex. 1011, 6:29–31, 16:42–46. Drive cycle modulation is “a technique to remove ambient and background signals.” *Id.* at 6:7–9. Drive cycle modulation operates by turning on a first light source, followed by a dark period, followed by a second light source, followed by a dark period, measuring the ambient light during the dark period and subtracting the ambient contribution from signal received during the first and second on periods. *Id.* at 6:11–19. Cardiac cycle modulation represents a lower frequency envelope function (about 1 Hz) on the higher frequency drive cycle (about 1 KHz). *Id.* at 6:26–30.

Figure 2C of Lisogurski is reproduced below.

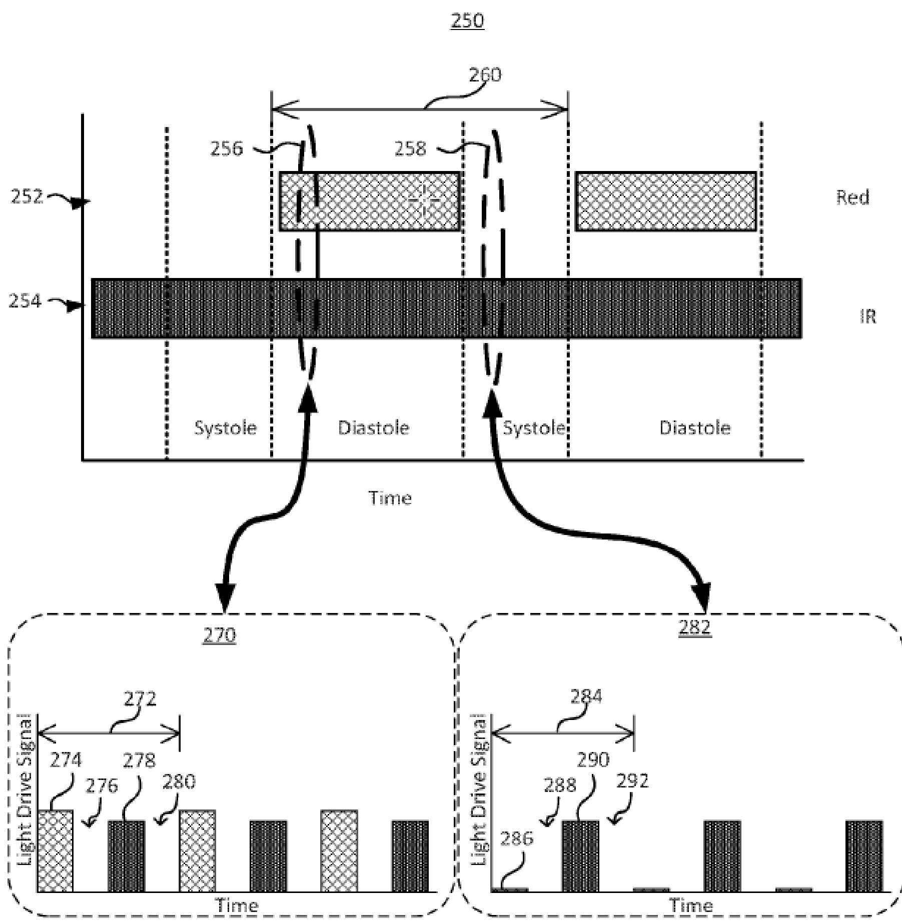

Figure 2C of Lisogurski

Figure 2C shows timing diagrams of drive cycle modulation and cardiac cycle modulation. *Id.* at 16:17–19. The period of the cardiac cycle modulation, i.e., time period 260, may be on the order of 1 second and the period of drive cycle modulation 272 may be on the order of 1 msec. *Id.* at 16:40–46. Plot 270 shows an illustrative portion of region 256, where both red light modulation 252 and IR modulation 254 are in an "on" portion of the cardiac modulation in the diastole. *Id.* at 16:33–38. Lisogurski explains:

> Time interval 272 may include a sequence of red "on" portion 274, a first "off" portion 276, IR "on" portion 278, and a second "off" portion 280. The first "off" portion 276 and second "off" portion 280 may be used to determine the level of ambient light, noise, dark current, other suitable signals, or any combination thereof. The system may subtract the background or dark level from the levels received during red "on" portion 274 and IR "on" period 278.

Id. at 16:47–53. Lisogurski provides a similar discussion of region 258 where red light modulation 252 is in an "off" portion of the cardiac cycle modulation and IR modulation is in an "on" portion of the cardiac cycle modulation. *Id.* at 16:54–17:10.

As discussed above, Lisogurski discloses combining cardiac cycle and drive cycle modulation techniques, "[f]or example, cardiac cycle modulation may be an envelope on the order of 1 Hz superimposed on a 1 kHz sine wave drive cycle modulation." *Id*. at 6:29–31. Lisogurski also states "[t]he system may use one or more cardiac cycle modulation techniques depending on the desired physiological parameter." *Id.* at 9:12–14. As an example, Lisogurski discloses that "the system may alter the cardiac cycle modulation technique based on the level of noise, ambient light, other suitable reasons" and "[i]n some embodiments, the system may change from a modulated light output to a constant light output in response to noise, patient motion, or ambient light." *See id.* at 9:45–60 (discussing options to reduce the effect of noise that can be implemented during a cycle of the cardiac cycle modulation).

2. Carlson

Carlson concerns optical pulsoximetry used for non-invasive measurement of pulsation and oxygenation in arterial blood. Ex. 1009 ¶ 2. An articulated object of Carlson is "define optical and/or electronic means for increasing the Signal-to-Noise ratio (S/N) and Signal to Background ratio (S/B) of a pulsoximeter sensor." *Id.* ¶ 10. Carlson seeks to improve S/N and S/B using one or more of the following techniques: beam shaping to direct optical radiation in a way that increases signal power (*id.* ¶ 14), employing light sources at more than one wavelength and optical wavelength filtering adapted to the power spectrum of the light source and absorption spectrum of the arterial blood (*id.* ¶¶ 16–17), and shifting the power spectrum of the pulsoximeter signals to a higher frequency range by temporarily amplitude modulating LED radiation using AC-Coupling or Lock-In Amplification. (*id.* ¶¶ 20, 27, 64–65).

Carlson recognizes that the spectrum of physiological event is within the range of 0.5–3 Hz (30–180 heartbeats per minute), sunlight is at 0 Hz, and artificial electrical light is about 120 Hz in the United States. Ex. 1009 ¶¶ 66–67, Figs. 7a–7b. Figure 7c of Carlson is reproduced below.

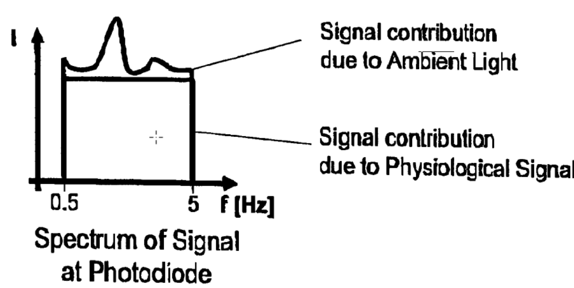

Figure 7c of Carlson

Figure 7c is a combined frequency spectrum showing the contribution of physiological signals, sunlight and ambient light. *Id.* ¶ 67. Carlson discloses discriminating the pulsoximeter sensor signals from the ambient noise by pulsing the LEDs at a frequency outside the range of sunlight or ambient light (e.g., at about f_o=1000 Hz, or some other higher frequency), thereby shifting the spectrum of signals from the photodiode to a range where there is little influence from the ambient noise. *Id.* ¶ 69, Fig. 8.

Figure 8 of Carlson is shown below.

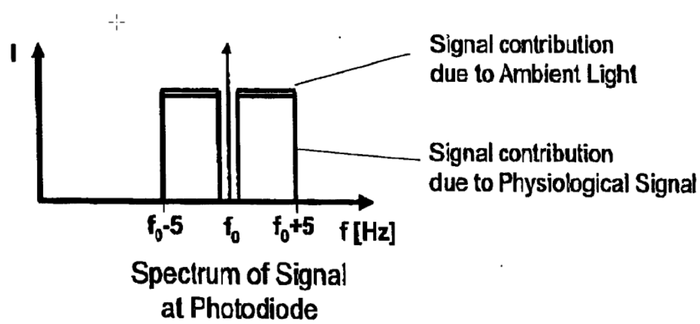

Figure 8 of Carlson

Figure 8 illustrates noise or sunlight in the range of 0–120 Hz contributes little to the pulsoximeter measurements between f_o–5 Hz and f_o+5 Hz.

Figure 9 of Carlson is reproduced below.

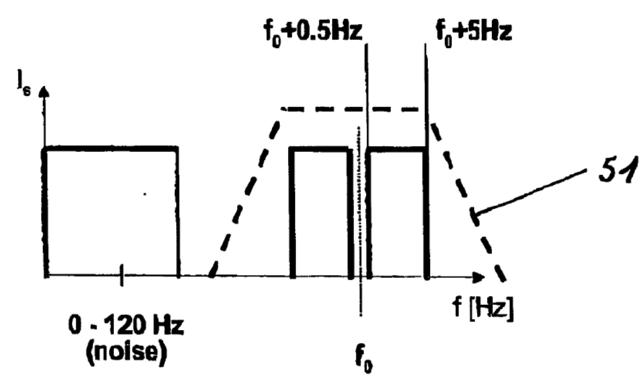

Figure 9 of Carlson

As shown in Figure 9, bandpass filter 51 can be used to remove any frequencies between 0 Hz and 120 Hz. *Id.* ¶ 69.

After measurements with pulse light have been executed, Carlson employs reverse phase shifting or modulation, as known in the art, to calculate the real values of the pulsoximetric measurement. *Id.* ¶ 70.

3. Reasons to Combine Lisogurski and Carlson

Petitioner notes that Lisogurski and Carlson both concern analogous miniaturized pulse oximetry devices that have the same applications. Pet. 24 (citing Ex. 1003, Declaration of Dr. Brian W. Anthony ("Anthony Decl.") ¶ 85). Petitioner also argues that Lisogurski and Carlson teach techniques for improving energy efficiency and signal-to-noise ratios in such devices. *Id.* at 24–25 (citing Ex. 1011, 1:4–6, 1:16–18, 3:50–53, 9:46–52; Ex. 1009 ¶¶ 2, 4, 10, 48, 52; Ex. 1003, Anthony Decl. ¶¶ 83–84). According to Petitioner, a person of ordinary skill would have considered the references together, given the common applications and utility. *Id.* at 25–26 (citing Ex. 1003, Anthony Decl. ¶ 85). Petitioner further argues that general trends in the industry to create wearable mobile monitoring devices in sports and personal fitness applications would have given a person of ordinary skill reason to look to the references to develop such devices for consumer applications. *Id.* (citing Ex. 1003, Anthony Decl. ¶¶ 48–56, 86).

Patent Owner asserts that the only time Lisogurski increases or decreases the LED firing rate is during cardiac cycle modulation (CCM). PO Resp. 26. According to Patent Owner, a person of ordinary skill could not combine Lisogurski with Carlson because CCM works by matching the LED firing rate to heart rate and heart rate can never be Carlson's rate of 1000 Hz. *Id.* We address this argument in more detail in our discussion below.

4. Claim Limitations 1(a)–1(k)

Petitioner cites Lisogurski as disclosing a system for measuring one or more physiological parameters for use with a smart phone or tablet, as recited in the preamble (claim limitation 1(a)), and that the system may be placed on a user's ear or wrist (claim limitation 1(b)). Pet. 27–28 (citing, e.g., Ex. 1011, 1:10–25, 3:43–46, 4:6–20; Ex. 1003 ¶¶ 89–92, 97 (Anthony Decl.)).

Petitioner also cites Lisogurski's wearable sensor as disclosing a plurality of LED light sources generating photonic signals having one or more wavelengths configured to direct light into a subject's tissue (claim limitation 1(c)); Petitioner further states that a person of ordinary skill would have understood that glass encapsulating LEDs serves as a lens, i.e., a basic building block of an optical sensor, to receive the LED's light and transmit that light to a particular location (claim limitation (d)). *See id.* at 29–30. Petitioner further argues that Carlson discloses such lenses and that they can be diffractive or refractive and direct the emitted optical radiation into human or animal tissue. *See id.* at 31–33 (citing, e.g., Ex. 1009 ¶¶ 13, 14, 24, 62; Ex. 1003, Anthony Decl. ¶ 111). According to Petitioner, a person of ordinary skill would have had reason to employ lenses as taught by Carlson in Lisogurski's sensor to focus light from the LED onto a person's skin and in doing so, increase optical power and improve signal to noise ratio. *Id.* at 32–33 (citing Ex. 1009 ¶ 14; Ex. 1011, 6:3–6, 9:49–60, 13:60–14:10, 14:40–55, 37:6–20; Ex. 1003, Anthony Decl. ¶¶ 82, 112–114.).

Claim limitation 1(e) recites "the wearable device further comprising a detection system configured to receive at least a portion of the lens output light reflected from the tissue and to generate an output signal having a signal-to-noise ratio." Petitioner cites Lisogurski as disclosing the recited detection system in the form of a sensor with one or more detectors connected to front-end processing circuitry that may receive a detection signal, i.e., light that is reflected by or has traveled through the subject's tissue, from detector 140, and provides processed signals, i.e., electrical signals based on the intensity of the reflected light, to back-end circuitry 170. Pet. 33–34 (citing Ex. 1011, 11:14–22, 12:42–45, 17:40–42; Ex. 1003, Anthony Decl. ¶ 116). Petitioner further notes that the processed signals originate from detection signals that have a signal-to-noise ratio. *Id.* at 34 (citing Ex. 1011, 14:49–50 (discussing the effect of ambient light on signal-to-noise ratio of the detection signal in the context of the available resolution of an A/D converter), 9:46–52 (noting background noise in the detected signal and modifying light drive parameters of the LEDs to improve signal-to-noise ratio), 11:20–27 (detection signal processed); Ex. 1003, Anthony Decl. ¶ 117).

Turning to claim limitation 1(f), which recites that the detection system is configured to be synchronized to the light source, Petitioner cites Lisogurski as disclosing front end processing circuitry 150 operating synchronously with light drive circuitry 120, e.g., by synchronizing the sampling rate of an analog to digital converter to a modulated LED firing rate to provide, e.g., one or more samples to be averaged per period. *Id.* at 34–35 (citing Ex. 1011, 2:1–2, 27:44–52, 33:49–47, 35:17–23; Ex. 1003, Anthony Decl. ¶¶ 119–121). Acknowledging that Lisogurski depicts front end processing circuitry 104 as separate from wearable sensor 102, Petitioner asserts that incorporating the front end processing circuitry into the same device with the detector would have been consistent with Lisogurski's teaching that the functionality of some components of monitor

104 can be divided over multiple components and is an obvious modification to a person of ordinary skill. *See* Pet. 36–38.

Petitioner cites Lisogurski as disclosing claim limitations 1(g) and 1(h). Pet. 38–40. Claim limitation 1(g) recites that the detection system comprises a plurality of multiple spaced detectors with at least one A/D converter coupled to at least one of the spatially separated detectors. Claim limitation 1(h) recites that a detector output from at least one of the spatially separated detectors is coupled to an amplifier to improve detection sensitivity.[8] Petitioner cites Lisogurski as disclosing that signals generated by the detectors are passed to front end processing circuitry that includes an A/D converter and an amplifier having a gain that can be adjusted so that the signal matches the range of the A/D converter to increase resolution and detection sensitivity. *Id*. (citing Ex. 1011, 11:9–10, 13:6–60, 17:43–45, 19:52–53, 19:56–58, 26:38–45; Ex. 1003, Anthony Decl. ¶¶ 129–131, 134–135).

Claim limitation 1(i) recites a smart phone or tablet comprising a wireless receiver, a wireless transmitter, a display, a speaker, buttons, a microprocessor, and a touch screen, configured to receive and process at least a portion of the output signal, such that a portion of the processed output signal is configured to be transmitted over a wireless transmission link. Petitioner cites Lisogurski as disclosing its sensor is designed to be used with a monitor that may be a portable, battery powered system that includes a touchscreen and has back-end processing that receives signals from the front end and includes a microprocessor and an interface with a

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[8] Claims 7 and 15 do not include a limitation corresponding to claim limitation 1(h). Pet. 39.

display, speaker, and microphone. *See* Pet. 40–42. Petitioner further notes that the back-end processing disclosed by Lisogurski can be configured for wireless communication. *Id.* at 40–41 (citing Ex. 1011, 15:49–56; Ex. 1003, Anthony Decl. ¶ 138).

Claim limitation 1(j) recites "a cloud configured to receive over the wireless transmission link an output status comprising the at least a portion of the processed output signal, to process the received output status to generate processed data, and to store the processed data." Petitioner cites Lisogurski as disclosing that physiological parameters and other data may be wirelessly transmitted to a server or a multi-parameter physical monitor (MPPM 326) that can be coupled to a network to enable sharing of information with servers or other workstations, i.e., a cloud based server. *See* Pet. 42–43.

Claim limitation 1(k) recites "the output signal is indicative of one or more of the physiological parameters[, and the cloud is configured to store a history of at least a portion of the one or more physiological parameters over a specified period of time]."[9] Petitioner cites Lisogurski as disclosing that data, i.e., an output signal, transmitted to a server, monitor, or remote device may be stored or published, that MPPM 326 is configured to calculate physiological parameters, and that these devices can perform historical analysis or prior cardiac cycles and calculate statistical information. *Id.* at 44 (citing Ex. 1011, 26:55–60, 18:49–53, 20:8–9, 19:1–19; Ex. 1003, Anthony Decl. ¶¶ 149–152).

Patent Owner does not respond to Petitioner's assertions concerning claim limitations 1(a)–1(k). *See generally* PO Resp. Having reviewed the

[9] The language in brackets does not appear in claims 7 and 15.

evidence of record, we find that Petitioner has demonstrated that Lisogurski teaches each of claim limitations 1(a)–1(k).

5. Claim limitation 1(l)

Petitioner identifies claim limitation 1(l) as reciting "the wearable device configured to increase the signal-to-noise ratio." Pet. 45. Petitioner cites Lisogurski as disclosing its control circuitry improves signal-to-noise ratio by providing signal modulation to vary light drive signal parameters such as light intensity (brightness), firing rate (frequency) and duty cycle (pulse width duration for each pulse of light). *Id.* at 45–48.

a) Claim Limitation 1(l)(1)

Petitioner identifies as claim limitation 1(l)(1) the recitation "[the wearable device configured to increase the signal-to-noise ratio] by increasing light intensity of at least one of the [plurality of] semiconductor sources from an initial light intensity." Pet. 48 (second alteration in original). Petitioner cites Lisogurski as disclosing that by increasing light intensity the system may increase the brightness of light sources in response to noise to improve signal to noise ratio. Pet. 48 (citing Ex. 1011, 37:6–22, 6:3–6; Ex. 1003, Anthony Decl. ¶¶ 145–48, 166–171). Lisogurski describes brightness (light intensity) as a parameter of the light drive signal, i.e., the signal that drives the LED. *See* Ex. 1011, 25:52–55. We also note that Lisogurski states the system may use "drive cycle modulation," i.e., a relatively higher frequency modulation technique having a period on the order of 1.6 msec, to generate one or more wavelengths of intensity signals. *Id.* at 5:48–51. Patent Owner does not respond to Petitioner's assertion that Lisogurski discloses claim limitation 1(l)(1). We find that Petitioner has demonstrated Lisogurski teaches this claim limitation.

b) Claim Limitation 1(l)(2) ("The Pulse Rate Limitation")

(1) Introduction

Petitioner identifies as claim limitation 1(l)(2) the recitation "[the wearable device configured to reduce the signal-to-noise ratio] . . . by increasing a pulse rate of at least one of the plurality of semiconductor sources from an initial pulse rate." Pet. 48. The pulse rate limitation is similar to a limitation recited in claim 13 of the '533 patent, which was the subject of the '916 IPR. Similar to the pulse rate limitation before us, claim 13 of the '533 patent recites "the light source configured to increase signal-to-noise ratio by . . . . increasing the pulse rate of at least one of the plurality of semiconductor sources." In the '916 IPR, the panel found that Lisogurski teaches the limitation recited in claim 13 of the '533 patent. *See* '916 IPR Final Written Decision (Paper 39) at 27–30 (PTAB Oct. 14, 2020) (Ex. 2125 in this proceeding). The panel further found that a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Carlson and their combined teachings also teach the limitations of claim 13 of the '533 patent. *Id.* at 30–35. The panel's decision was affirmed by the Federal Circuit under Fed. Cir. Rule 36. *See Omni MedSci, Inc. v. Apple Inc.*, No. 2021-1229, 2022 WL 2062168, at *1 (Fed. Cir. June 8, 2022) (non-precedential). For the reasons discussed below, we reach the same conclusion as to the pulse rate limitation before us.

(2) The Parties' Positions

According to Petitioner, a person of ordinary skill "would have understood that an LED's 'firing rate' is the same as the claimed 'pulse rate.'" Pet. 49 (citing Ex. 1003, Anthony Decl. ¶¶ 175–176). Petitioner notes that Lisogurski teaches regulating a light drive signal, i.e., electric current applied to LEDs and that LEDs can be modulated by controlling "drive cycle parameters" such as light intensity, duty cycle, and light source firing rate. Pet. 22 (citing Ex. 1011, 1:19–21, 1:60–61, 1:67–2:3, 5:48–54 (describing "drive cycle modulation" on the order of 1.6 msec to generate one or more wavelengths of intensity signals)), 7:13-16, 7:24-31, 8:4–8 (noting that the system may use pulse rate or other elements of the cardiac cycle in part to control the light drive signal), 8:27–35 (stating that "cardiac cycle modulation may be used in addition to a drive cycle modulation"), 12:3–9 (describing the light drive signal as controlling the "on" and "off" periods of red and IR emitters), 12:16–22, 16:25–32 (discussing Figure 2C, which is a timing diagram of drive cycle modulation and cardiac cycle modulation), 25:53–55); *see also* Pet. 45 (noting that light drive signal parameters include brightness (intensity), frequency (firing rate), and pulse width, i.e. the duration of each pulse of light (duty cycle) (citing Ex. 1003, Anthony Decl. ¶ 158)). The Petition also states that "Lisogurski explains that *varying the drive cycle parameters* can increase the signal-to-noise ratio when interference is encountered". Pet. 22 (emphasis added) (citing Ex. 1011, 5:55–6:6, 9:46–52, 27:44–49 ("modulation of the light drive signal . . . may include modulation of parameters including light drive current or light brightness, duty cycle, firing rate, . . . or any combination thereof")); Ex. 1003, Anthony Decl. ¶¶ 74, 76–77).

Petitioner advances two arguments that Lisogurski discloses the pulse rate limitation. First, Petitioner argues that a "skilled person would have recognized that a light source must have an initial firing rate ('initial pulse rate') that the system can later change." Pet. 49 (citing Ex. 1003, Anthony Decl. ¶ 176); *see also* Ex. 1003, Anthony Decl. ¶¶ 178–180; Pet. Reply 3 (citing Pet. 48–51). Petitioner contends that Lisogurski teaches this feature by describing embodiments in which the pulse rate of the LED is correlated to the sampling rate of an analog-to-digital converter in the detector. *Id.* at 49 (citing Ex. 1011, 33:47–49 ("sampling rate modulation may be correlated with light drive signal modulation")); Ex. 1003, Anthony Decl. ¶ 178. According to Petitioner, by increasing firing rate from an initial rate to correlate the firing rate to the sampling rate of an analog-to-digital (A-D) converter, Lisogurski improves signal-to-noise ratio by spreading the noise across more samples. Pet. 49–51, (citing Ex. 1011, 9:46–52, 37:6–22; Ex. 1003, Anthony Decl. ¶¶178–180, 182). Petitioner further argues that the cross-examination testimony of Patent Owner's expert Dr. Duncan MacFarlane supports Petitioner's contention that increasing the LED pulse rate improves signal-to-noise ratio. Pet. 50 (citing Ex. 1060, Transcript of Deposition of Dr. Duncan Leo MacFarlane ("MacFarlane Tr.") 37:13–38:3, 82:5–15). Dr. MacFarlane testified that "[g]enerally speaking the faster the modulation, the faster the pulse rate, the lower the background noise" (MacFarlane Tr. 37:17–19) unless "increasing the pulse rate of the LED changes the signal or moves you into a regime where there's more noise, then the effect of the signal-to noise ratio may not be an increase" (*id.* at 84:1–4). Patent Owner provides no evidence that, in the context of the relevant device technology, increasing pulse rate of the LED moves one into a regime where there is more noise.

Petitioner's second argument is that cardiac cycle modulation (CCM) varies the light drive signal to remain synchronous with a subject's heart rate, thereby increasing the pulse rate as the subject's heart rate increases and reducing noise by 1–4%. Pet. 50–51 (citing Ex. 1011, 25:46–55, 25:50–61; Ex. 1003, Anthony Decl. ¶¶ 181–182).

Patent Owner attempts to recharacterize Petitioner's contentions, stating that "both arguments rely on the same disclosure regarding Lisogurski's CCM," and that "[Petitioner] cites and discusses only Lisogurski's descriptions of CCM and [Petitioner] does not cite or discuss 'firing rate' changes other than in CCM." PO Resp. 15 (citing Ex. 2136, MacFarlane Decl. ¶ 88). According to Patent Owner, as support for its argument that Lisogurski can dynamically adjust parameters for light emitted by LEDs, Petitioner cites Lisogurski's disclosure that the system may modify the cardiac modulation technique. *Id.* at 16 (citing Pet. 48; Ex. 1011, 9:46–52, 37:6–22). Patent Owner further contends that Petitioner's discussion of sampling rate is irrelevant to the pulse rate limitation, because "any SNR [signal to noise ratio] improvement from ***sampling*** rate changes do not meet the claim requirement of increasing the LED ***pulse*** rate. *Id.* (citing Pet. 49; Ex. 2136, Declaration of Dr. Duncan L. MacFarlane ("MacFarlane Decl.") ¶ 90).

(3) The Sampling Rate Argument

As to its sampling rate argument, Petitioner replies that "Lisogurski expressly correlates sampling rate and LED firing (*pulse*) rate, stating that 'decreasing the duration of the 'off' periods (i.e., ***increasing the emitter firing rate***) relates to an **increased sampling rate.**'" Pet. Reply 5 (citing Ex. 1011, 35:24–31, Fig. 2A (showing a light drive signal in which "off" period 220 is the time between LED pulses)). Patent Owner counters that Lisogurski does not use the term "sampling rate" to refer to the LED firing rate and that the light drive signal, i.e., the signal that controls the emitter firing rate, is not the sampling rate. PO Sur-reply 1–5.

Petitioner does not argue that the emitter firing rate is the sampling rate. As Patent Owner points out, the Petition refers to the sampling rate of an analog-to-digital converter in the detector. *Id.* at 3 (citing Pet. 49). The Petition asserts that Lisogurski discloses the pulse rate limitation because it teaches a relationship or correlation between emitter firing rate and the sampling rate. Pet. 49–51. Dr. Anthony notes that Lisogurski explicitly states "increasing the sampling rate for a portion of the cardiac cycle may result in more accurate and reliable physiological information." *See* Ex. 1003, Anthony Decl. ¶ 183 (quoting Ex. 1011, 33:56–58). The portion of Lisogurski Dr. Anthony cites discloses sampling at one rate during less critical parts of the cardiac cycle to conserve power and sampling at a higher rate at other parts of the cardiac cycle to improve accuracy. Lisogurski's modulation of sampling rate with the cardiac cycle is significant, because Lisogurski discloses "[i[n some embodiments, sampling rate modulation may be correlated with light drive signal modulation." Ex. 1011, 33:47–49.

Petitioner's argument is consistent with its assertion that "Lisogurski explains that varying the drive cycle parameters can increase signal-to-noise ratio of the device when interference is encountered." Pet. 22 (citing Ex. 1011, 5:55–6:6, 9:46–52; 27:44–49; Ex. 1003, Anthony Decl. ¶¶ 74, 76–77). Petitioner's arguments are further supported by Lisogurski's disclosure that "front end processing circuitry **150** may synchronize the operation of an analog-to-digital converter and a demultiplexer with the light drive signal based on timing control signals." Ex. 1011, 11:33–49. In view of these disclosures, we find that, based on its sampling rate argument, Petitioner has demonstrated Lisogurski teaches the pulse rate limitation.

(4) CCM Argument

Turning to Petitioner's argument that CCM varies the light drive signal to remain synchronous with a subject's heart rate, Patent Owner contends that the Petition relies solely on Lisogurski's disclosure of CCM and that Lisogurski's CCM does not increase signal-to-noise ratio. PO Resp. 15–24. According to Patent Owner, "[Petitioner] cites and discusses only Lisogurski's descriptions of CCM and [Petitioner] does not cite or discuss 'firing rate' changes other than in CCM." *Id.* at 15.

According to Patent Owner, Petitioner's argument that Lisogurski's system can dynamically adjust the parameters of light emitted by LEDs is not supported by the subject matter Patent Owner cites in Lisogurski because that subject matter is expressly directed to CCM. *Id.* at 16 (citing Pet. 48, supported by Ex. 1011, 9:46–52, 37:6–22). Patent Owner disputes that the firing rate in Petitioner's discussion of the pulse rate limitation refers to the pulse rate of the LED and not the rate of CCM and identifies several passages of Lisogurski cited in the Petition that purportedly disclose the firing rate is linked to a subject's heart rate. PO Resp. 17–18 (citing Ex. 1011, 25:46–61, 25:66–26:14, 42:50–54; Ex. 1003, Anthony Decl. ¶¶ 181–182; Ex. 2125, 29[10]). This argument by Patent Owner is unavailing, as Petitioner's expert explicitly testified that "firing rate refers to the number of times the light is turned on and off" and that "[a] person of ordinary skill would understand that the 'firing rate' of an LED is the same as the claimed 'pulse rate' because both terms refer to the rate or frequency at which the LED is turned on and off." Ex. 1003, Anthony Decl. ¶¶ 175–176.

We now consider whether, in the context of the pulse rate limitation, Lisogurski discloses improving signal-to-noise ratio by the application of CCM alone. Patent Owner cites the testimony of Dr. MacFarlane that CCM would have no measurable effect on SNR "because the LED firing rate is

[10] *Apple Inc. v. Omni MedSci, Inc.*, IPR2019-00916 Final Written Decision (Paper 39) (PTAB Oct. 14, 2020), aff'd., Case No. 2121-1229 (Fed. Cir. June 8, 2022) Fed. Cir. R. 36 (non-precedential).

varied just a few hertz, from 0.5 Hz to 3 Hz, the frequency range of the human cardiac cycle." PO Resp. 21–23 (citing Ex. 2136, McFarlane Decl. ¶ 81). The Patent Owner Response reproduces Dr. McFarlane's declaration discussing paragraph 66 of Carlson and including a diagram created by Dr. MacFarlane showing a uniform distribution of noise in the 0.5–10 Hz range superimposed on an LED firing rate of 0.5–3 Hz. *Id.* at 22–23 (citing Ex. 2136, MacFarlane Decl. ¶ 81[11], referencing Ex. 1009 ¶ 66). Petitioner cites Carlson as demonstrating that ambient light noise is not uniform in the range of 1–10 Hz, as posited by Dr. MacFarlane, because ambient light peaks near 0 Hz and trails off. *Id.* (citing Ex. 1009, Fig. 7b). Figure 7c of Carlson, which compares the signal contribution from ambient sunlight to that of a physical physiological signal, shows spikes at a frequency substantially below 5 Hz. Ex. 1009, Fig. 7c.

Petitioner notes Lisogurski discloses that, when applying physiological pules in CCM, "particular segments of a respiratory cycle may provide an increased signal to noise ratio." Pet. Reply 6 (citing Ex. 1011, 25:66–26:14). Lisogurski also states "it may be desired to correlate a modulation technique with respiration variations or both respiration variations and cardiac pulses." Ex. 1011, 26:12–14.

Petitioner further argues that Patent Owner's arguments are contradicted by Lisogurski's disclosure concerning improvements in signal-to-noise ratio in the presence of Gaussian noise of 0–5 Hz. Pet. Reply 7–8. Petitioner notes that in the presence of Gaussian noise from 0–5Hz, a shift

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[11] The Patent Owner Response incorrectly cites Ex. 2136 ¶ 81; the Patent Owner Response actually reproduces paragraph 83 of the MacFarlane Declaration (Ex. 2136 ¶ 83).

from 1 Hz to 2Hz or 3 Hz (e.g., from 60 beats per minute to 120 or 180 beats, is significant). *Id.* fn.3; *see also,* Ex. 1009 ¶ 66.

Lisogurski discloses a system that may alter the CCM technique based on noise or ambient light and may be used with or without other forms of modulation. Ex. 1011, 9:45–60 (disclosing that the system may alter the light drive signal by increasing the brightness of the light source in response to noise to improve signal-to-noise ratio and, in some embodiment, increase the light source brightness throughout the cardiac cycle; the system also "may change from a modulated light output to a constant light output in response to noise, patient motion, or ambient light.").

The Petition cites Lisogurski's disclosure at column 42, lines 45–58 stating that for pulse amplitude calculation techniques in the presence of moderate noise, the systole period CCM shown in Figure 26 may provide improved performance. Pet. 51. Figure 26 of Lisogurski illustrates simulated photoplethysmography (PPG) signal 2602, systole period modulated PPG signal 2604 and diastole period modulated PPG signal 2606 in the presence of moderate Gaussian noise between 0–5Hz. Ex. 1011, 41:40–49. According to Lisogurski "[t]he signals provide examples that illustrate when cardiac cycle modulation is properly selected, the accuracy of monitoring functions can be enhanced." *Id.* at 41:49–52. *See generally id.* at 41:40–42:58 (describing the CCM applied). As the subject matter Petitioner cites in Lisogurski points out, the simulated waveforms of Figure 26 illustrate that

> noise contributes coefficients of variation of 2.6%, 1.9% and 3.8% to computed pulse amplitudes of PPG signal 260, systole period modulated PPG signal 2604, and diastole period modulated PPG signal 2606, respectively. Accordingly, for pulse amplitude calculation techniques in the presence of

> moderate noise, the systolic period cardiac cycle modulation technique may provide improved performance.

Pet. 50–51 (citing Ex. 1011, 42:50–54). Petitioner points out that the challenged claims do not recite any specific level of improvement in signal-to-noise ratio—the claim limitation merely recite an improvement. *See* Pet. Reply 9. Having considered the scope of the claims and the arguments and evidence of record, we conclude that Petitioner has demonstrated that Lisogurski discloses the application of CCM alone improves signal-to-noise ratio and teaches the pulse rate limitation.

(5) Lisogurski and Carlson

Petitioner's third argument is that, based on the combined teachings of Lisogurski and Carlson, the pulse rate limitation would have been known to an ordinarily skilled artisan. Petitioner cites Carlson as expressly disclosing shifting the frequency of emitted light during operation from a first frequency to a second frequency, so it is substantially outside the frequency of noise and environmental signals. Pet. 52 (citing Ex. 1009, claim 10–11, ¶¶ 67–69); (*see* Ex. 1003, Anthony Decl. ¶¶ 186–188). Petitioner contends that in view of Carlson's recognition that sunlight interference is temporary and can occur at different frequencies, a person of ordinary skill would have recognized that the pulse frequency can vary. Pet. 52 (citing Ex. 1009 ¶ 68; Ex. 1003, Anthony Decl. ¶ 187; *see also* Ex. 1003, Anthony Decl. ¶¶ 188–190).

Petitioner contends that a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Carlson because both references identify and address the same problem, i.e., the negative impact of ambient light on signal-to-noise ratio. Pet. 53 (citing Ex. 1011, 9:46–60; Ex. 1009 ¶¶ 67–69; Ex. 1003, Anthony Decl. ¶ 190). Petitioner contends that, because Lisogurski teaches adjusting LED firing rate in response to changing environmental conditions such as background noise or ambient light, a skilled artisan would have recognized Lisogurski could be configured to increase LED firing rate as taught by Carlson. *Id.* (citing Ex. 1011, 1:67–2:3, 5:55–61, 9:46–60, 37:6–18; Ex. 1009 ¶¶ 67–69; Ex. 1003 ¶¶ 190–191 (Anthony Decl.)). Dr. Anthony states that even if Lisogurski alone does not teach increasing the firing rate of the LED to improve signal-to-noise ratio, based on Lisogurski's discussion of increasing brightness, a person of ordinary skill would have had reason to consider additional ways of improving signal-to-noise ratio. Ex. 1003 ¶¶ 185, 190. Recognizing that firing rate is among the light drive signal parameters that can be adjusted, a person of ordinary skill would have had reason to employ Carlson's technique that temporarily increases the firing rate (or pulse rate of the LED) to a range that mitigates the effect of noise arising from transient ambient conditions, while avoiding excess battery power drain. Ex. 1003, Anthony Decl. ¶¶ 186–188, 190.

Patent Owner contends that modifying Lisogurski's CCM with Carlson would change CCM's principle of operation. PO Resp. 26–32. Patent Owner emphasizes that Lisogurski discloses the CCM should remain synchronous with a chosen point in the physiological signal, e.g., changing at a rate between 0.5 and 3.0 Hz. *Id.* at 28–30. According to Patent Owner, by modulating the firing rate of the LED at frequencies outside the CCM range, e.g., at 1000 Hz as taught by Carlson, "the CCM firing rate would no longer be synchronous with the heart rate" and "would change the core principle of operation of Lisogurski's CCM." *Id.* at 30.

Petitioner disputes Patent Owner's assertion that "configuring Lisogurski to increase LED pulse rate to avoid noise would change its principle of operation because doing so would break CCM which tracks the subject's heart rate (0.5–3Hz)." Pet. Reply 1. Petitioner emphasizes that "Lisogurski *explicitly teaches* changing LED pulse rate when using other modulation types, including drive cycle modulation [DCM], which would not affect CCM's principle of operation" and "Lisogurski teaches simultaneously using both CCM and DCM, which will cause the LED firing rate to be raised to 1,000 Hz during CCM." Pet. Reply 1–2 (citing Ex. 1011, 35:10–30, 25:58–65, 37:18–22, 6:31).

Patent Owner acknowledges that Lisogurski discloses that DCM and CCM can occur simultaneously, but argues that Lisogurski never suggests changing a DCM firing rate. PO Resp. 19 (citing Ex. 2136, MacFarlane. Decl. ¶¶ 97–98); PO Sur-reply 5. According to Patent Owner, Petitioner "cites no evidence that Lisogurski discloses 'firing rate' increases other than as a part of CCM." *Id.* at 18 (citing Ex. 2136, McFarlane Decl. ¶¶ 94–95 (referring to this subject matter as Petitioner's second Lisogurski alone argument)).

This argument by Patent Owner is contradicted by Lisogurski's disclosure of correlating LED firing rate and sampling rate, as discussed above. Lisogurski's discussion of CCM states "the system may require an accurate time and amplitude for the peak and foot of a pulse and less accurate sampling of the rising or falling waveform and may modulate the light accordingly." Ex. 1011, 9:25–28. As noted by Petitioner's expert, "Lisogurski explains that sampling rate (and therefore LED firing rate) can be varied for the same reasons that light brightness is varied." Ex. 1003, Anthony Decl. ¶ 183 (quoting Ex. 1011, 35:5–9, "sampling rate is one of the components that may be modulated in cardiac cycle modulation as described above. It will also be understood that the earlier described embodiments relating to varying light output may also apply to sampling rate."); *see also* Ex. 1011, 27:9–27 (disclosing modulating the light drive signal in a way related to the cardiac cycle, e.g., by turning a light source on and off before and after a diastole period to allow the detector to stabilize, so that the processing equipment can obtain extra samples; thus, even as the light source is turned on an off based on cardiac rhythm, the timing is adjusted to allow more samples).

As evidence that Petitioner relies only on CCM, Patent Owner's expert cites Lisogurski's disclosure at column 25, lines 46–61 that "[t]he system may generate a light drive signal that varies with a period the same as or closely related to the period of the cardiac cycle, thus generating a cardiac cycle modulation . . . [t]he system may use a cardiac cycle modulation that spans several cardiac cycles." *See* Ex. 2136, MacFarlane Declaration ¶ 94. The subject matter cited by Dr. McFarlane was also cited in the Petition (*see* Pet. 50) and does not support Patent Owner's contentions. PO Resp. 20–24. The subject matter Dr. MacFarlane cites explicitly states that the *light drive signal* can be varied based on cardiac cycle modulation. Lisogurski explicitly states that the light drive signal is characterized by multiple parameters that can be varied, e.g., intensity and firing rate. *See* Pet. 46 (citing Ex. 1011, 25:52–55).

The Petition states:

> Lisogurski explains that its system can dynamically adjust the parameters of light emitted by the LEDs to ensure an adequate signal-to-noise ratio. Ex.1011, 9:46-52; *id.*, 37:6-22. These parameters include "drive current or light brightness, duty cycle, [and] ***firing rate***" among others. Ex.1011, 27:44-52; *id.*, 2:1-2 ("light source firing rate"), 8:29-35, 25:46-55; Ex.1003, ¶175.

Pet. 48–49. The text cited by Dr. MacFarlane supports Petitioner's arguments. The cited text states:

> [t]he system may generate the light drive signal such that a *parameter* of the emitted one or more photonic signals varies substantially synchronously with the physiological pulses of the subject. For example, the light drive signal varies with a period the same as or closely related to the cardiac cycle, thus generating a cardiac cycle modulation.

Ex. 1011, 25:46–52 (emphasis added). The subject matter cited by Dr. MacFarlane further explains:

> The system may vary parameters related to the light drive signal including drive current or light brightness, duty cycle, firing rate, modulation parameters, other suitable parameters, or any combination thereof . . . It will be understood that the system may apply this cardiac modulation to the light drive signal in addition to a drive cycle modulation, as illustrated in Fig. 2C, and conventional servo algorithms.

Id. at 25:52–64.

Petitioner's expert testified that a person of ordinary skill would have understood the subject matter cited by Dr. MacFarlane to mean

> that Lisogur[sk]i's device varies its light drive signal parameters, such as firing rate, to remain "substantially synchronous[] with" a subject's heart rate." Ex.1011, 25:46-49. see id., 25:50-61. Such a person would have further understood these disclosures mean that Lisogurski's "cardiac cycle modulation" causes the device to correlate its firing rate with a subject's heart rate. Such a person would have recognized the device will increase its firing rate whenever a patient subject's heart rate increases. Thus, Lisogur[s]ki's device will increase its pulse rate to remain synchronous with a subject's heart rate resulting in an increased signal-to-noise ratio being detected.

Ex. 1003, Anthony Decl. ¶ 182. Thus, Lisogurski teaches a system that may vary the parameters that characterize the light drive signal in a way that is correlated to some physiological measurement, such as heart rate. Ex. 1011, 25:46–52; *see also id.* at 1:41–48, 8:4–26, 31:11–24, 31:39–55. The parameters that characterize the light drive signal include drive current, light brightness, duty cycle, firing rate, modulation parameters, and other suitable parameters. *Id.* at 25:52–55, 31:44–52. During CCM, the parameters that characterize the light drive signal may vary with the cardiac cycle. In these circumstances, CCM does not set the intensity, the firing rate, or any of the parameters. Instead, CCM controls how those parameters may be varied or changed. *See* Ex. 1011, 25:46–49 ("The system may generate a light drive signal such that *a parameter* of the emitted one or more photonic signals varies substantially synchronously with physiological pulses of the subject." (emphasis added)); *see also id.* at 31:39–55. As Petitioner's expert points out, Lisogurski explicitly discloses that firing rate is one of the parameters of the light drive signal that may be modulated during CCM. Ex. 1003, Anthony Decl. ¶ 182; Ex. 1011, 31:39–55 ("the system may align modulation with pulses of the heart . . . modulation of the light drive signal . . . . may include modulation of parameters including . . . firing rate . . ."); *see also id.* at 27:40–55. Thus, when CCM is applied, a light drive signal parameter, such as the firing rate, signal intensity, or duty cycle, can vary from its current value to a different value synchronously with CCM. The actual value of each parameter (intensity, firing rate, duty cycle) is not determined by the CCM, e.g., although the intensity or firing rate may change from a first value to a second value synchronously with heartrate, those values are not determined by CCM. Indeed, Lisogurski explicitly describes CCM as "a lower frequency envelope on the higher frequency drive cycle." Ex. 1011, 6:26–30 (stating CCM "may be an envelope on the order of 1 Hz imposed on a 1KHz sine wave drive cycle modulation."). 1KHz is the same firing rate as taught by Carlson.

Patent Owner suggests that the Board, in the Institution Decision, improperly cites to text not relied on by Petitioner. PO Resp. 19. Patent Owner's contentions are unavailing. The Institution Decision does not introduce a ground or even a new argument. The Institution Decision cites 3 additional lines of text that begin on the same line (column 25, line 61) of Lisogurski; at column 25, lines 61–64 Lisogurski states that "the system may apply this cardiac modulation to the light drive signal *in addition to* a drive modulation, as illustrated in Figure 2C." Dec. to Inst. 32 (citing Ex. 1011, 25:61–64). The Institution Decision's citation of three lines of text beginning on the same line as the last line cited by Petitioner merely provides additional context to Lisogurski's previous articulation of the principle that parameters of the light drive signal vary synchronously with the physiological pulses, i.e., CCM can be used with drive cycle modulation. *See also* Ex. 1011, 8:4–26. Petitioner's discussion of CCM as synchronous with physical parameters does not change the fact that a fundamental aspect of Lisogurski is the use of CCM to vary parameters of the light drive signal, i.e., drive cycle modulation, as cited several times in the Petition. *See* Ex. 1011, 16:17–17:29, Fig. 2C, *see also* Pet. 22 (citing, Ex. 1011, 16:25–32, for the proposition that Lisogurski teaches that LEDs can be modulated), *id.* at 54 (citing Ex. 1011, 16:33–54), *id.* at 57, (citing Ex. 1011, 16:51–54 as describing dark subtraction), and *id.* at 56 (citing Ex. 1011, 16:52–53 as disclosing the system generating a red signal and an IR signal).

In any case, as discussed above, Petitioner cites Carlson as demonstrating that ambient light noise is not uniform in the range of 1–10 Hz, as posited by Dr. MacFarlane (Ex. 2136 ¶ 83), because ambient light peaks near 0 Hz and trails off. Pet. Reply 8, fn. 3 (citing Ex. 1009, Fig. 7b). Figure 7c of Carlson, which compares the signal contribution from ambient sunlight to that of a physical physiological signal, shows spikes at a frequency substantially below 5 Hz. Ex. 1009, Fig. 7c. Carlson also articulates the principle that "one may emit light by the LEDs not as current or continuous light, but as pulsed light." *Id.* ¶ 69. To avoid the influence of other environmental factors, such as artificial electric light and tree shadows, Carlson suggests setting the LED pulse rate to be "outside the frequency spectrum of sunlight and ambient light," e.g. around 1000 Hz. As noted above, this is consistent with Lisogurski's disclosure of CCM as an envelope around a drive cycle modulation of 1 KHz.

Having considered the arguments and evidence of record, we conclude that the combined teachings of Lisogurski and Carlson would have disclosed or suggested the pulse rate limitation to a person of ordinary skill in the art.

6. Claim Limitations 1(m)–1(o)

Claim limitation 1(m) recites the detection system generates a first signal responsive to light received while the LEDs are off; claim limitation 1(n) recites the detection system generates a second signal responsive to light when at least one of the LEDs is on. Claim limitation 1(o) recites the detection system is configured to increase the signal-to-noise ratio by differencing the first and second signals.

As to claim limitation 1(m), Petitioner cites Lisogurski as disclosing the front end processing uses the current measured when the LEDs are off to generate a dark signal representative of ambient light. Pet. 54–55 (citing Ex. 1011, 6:12–19, 11:14–16, 12:59–13:6, 13:67–14:6, Figs. 2A–B; Ex. 1003 ¶¶ 197–198 (Anthony Decl.)). As to claim limitation 1(n), Petitioner cites Lisogurski as disclosing the front end processing circuitry measuring the signal when at least one LED is on to capture a portion of the optical beam, e.g., a red signal and an IR signal, reflected from the tissue. *Id.* at 55–56 (citing Ex. 1011, 6:12–19, 11:12–20, 13:35–41, 13:67–14:2, 16:52–53, 17:8–10, 17:40–42, Figs. 2A–B; Ex. 1003 ¶¶ 200–202 (Anthony Decl.)).

Turning to claim limitation 1(o), noting that Lisogurski describes ambient light as noise, Petitioner cites Lisogurski as disclosing a "dark subtraction" technique that subtracts the dark signal from the red and IR signals to generate adjusted red and IR signals with noise removed, thereby improving signal-to-noise ratio. *Id.* at 54, 57 (citing Ex. 1011, 6:7–19, 13:60–14:10, 16:33–54 (describing the dark subtraction process); Ex. 1003 ¶¶ 194, 204–206 (Anthony Decl.)).

Patent Owner does not contest Petitioner's contentions concerning claim limitations 1(m)–1(o). Having reviewed the evidence and arguments of record, we find that Petitioner has demonstrated sufficiently that Lisogurski discloses claim limitations 1(m), 1(n), and 1(o) to a person of ordinary skill.

a) Conclusion as to Claim 1

Having reviewed the evidence and arguments of record, we find that Petitioner has demonstrated that a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Carlson and that the Lisogurski alone and the combined teachings of Lisogurski and Carlson would have disclosed or suggested the limitations of claim 1 to an ordinarily skilled artisan. Thus, we conclude that Petitioner has established by a preponderance of the evidence that claim 1 is unpatentable.

7. Claims 7 and 15

We addressed the differences between claim 1 and claims 7 and 15 in our discussion of the individual limitations of claim 1 as being inconsequential to patentability. *See, e.g.,* Section VI.B, fn. 8, 9 *supra*. In addition, we noted claim 15 does not recite the pulse rate limitation that is the primary focus of the dispute between the parties. Having reviewed all the evidence and arguments of record, and applying the same reasoning to the limitations of claims 7 and 15 that are similar to those of claim 1, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claims 7 and 15 are unpatentable.

8. Claim 17

Claim 17 depends from claim 15 and recites the additional limitation "wherein a detector output from at least one of the plurality of spatially separated detectors is coupled to an amplifier having a gain configured to be adjusted to improve detection sensitivity." In support of its argument that Lisogurski discloses the additional limitation recited in claim 17, Petitioner cites its arguments concerning claim limitation 1(g). Pet. 57–58 (citing *id.* at 38–39); *see also id.* at 39–40 (discussion of claim limitation 1(h)). Patent Owner does not contest Petitioner's arguments concerning the additional limitation recited in claim 17. Having reviewed the evidence and arguments of records, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claim 17 is unpatentable.

C. Claims 1–4, 7–12, and 15–22 As Obvious Over Lisogurski, Carlson, and Tran

Petitioner asserts that, to the extent Lisogurski is found not to teach a smartphone or tablet, Tran provides this teaching. Pet. 58. Petitioner further asserts that Tran discloses the limitations of dependent claims 2–4, 8–12, 16, and 18–22 that relate to artificial intelligence.

1. Tran (Ex. 1064)

Petitioner cites Tran as disclosing a heart monitoring system in which a monitoring device, such as a watch worn by patient, communicates health information to a server that passes the information to statistical and data driven analyzers. Pet. 58 (citing Ex. 1064, (code 57), 8:28–53, 9:23–54, 11:1–31, 54:14–57; Ex. 1003, Anthony Decl. ¶ 209). Petitioner notes that Tran's monitoring device can be used with a smartphone that collects data when a patient is away from home, that the monitored health information includes pulse oximetry measurements, and that the statistical analyzers use artificial neural networks to help track and classify patient risk and provide warnings. *See id.* at 58–59.

2. Reason to combine

Petitioner asserts that a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Carlson with those of Tran as part of the ordinary design process for such devices and systems. Pet. 59 (citing Ex. 1003 ¶¶ 210–214 (Anthony Decl.)). Noting that Lisogurski discloses processing its collected data to track patient status, Petitioner argues a person of ordinary skill would have been motivated to seek additional ways to use tracked data, such as pulse oximetry data, in a remote or mobile scenario, e.g., using Tran's artificial neural network to analyze such data and provide warnings. *Id.* (citing Ex. 1064, 22:23–28; Ex. 1011, 15:43–65, 18:58–65; comparing Ex. 1064, 36:62–37:13 with Ex. 1011, 10:48–64).

Patent Owner contends that this ground fails as to all challenged claims because Petitioner has not identified with particularity evidence of any motivation to combine all three references. PO Resp. 33–35. Patent Owner acknowledges that the Petition addresses reasons to combine Tran and Lisogurski, but contends that Petitioner offers no motivation to combine Tran and Carlson or Tran, Lisogurski, and Carlson. *Id.* at 34. According to Patent Owner, Petitioner's arguments that Lisogurski, Carlson, and Tran are analogous references is insufficient basis for a motivation to combine their teachings. *Id.*

Petitioner responds that the Petition demonstrates an ordinarily skilled artisan would have been motivated to find additional ways to analyze and use data collected by Lisogurski's device, based on ordinary design processes and market trends. Pet. Reply 18 (citing Pet. 10–11, 26, 59). Petitioner further contends that its explanation of reasons to combine is sufficient because the Petition showed why an ordinary skilled artisan would incorporate features from Carlson and Tran into Lisogurski. *Id.* at 19.

We agree with Petitioner that Lisogurski, Carlson, and Tran each describe techniques applicable to measurements taken by wearable optical sensing device. *See* Pet. 60. We also agree that Petitioner has demonstrated a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Carlson to improve the performance of Lisogurski's device and the accuracy of the data acquired by Lisogurski's device. Petitioner has also demonstrated that a person of ordinary skill would have looked to Tran for a slightly different purpose, i.e., to improve how the data obtained by Lisogurski's device is stored and analyzed. Thus, we conclude that Petitioner has demonstrated a person of ordinary skill would have reason to combine the teachings of these references.

3. Claims 1, 7, 15 and 17

As to independent claims 1, 7, 15, and 17, Petitioner argues that a person of ordinary skill would have recognized Tran's smartphone could be used in place of Lisogurski's monitoring device, which Lisogurski describes as a computing device that is portable, battery powered, and has a touchscreen. Pet. 60 (citing Ex. 1003, Anthony Decl. ¶ 216). Petitioner further notes that Tran teaches using a smartphone with a portable, wearable sensor to send data to remote devices and other monitoring devices, facilitating the detection of emergencies in a manner consistent with the use of smartphones and tablets. *See id.* at 60–61.

Beyond Patent Owner's arguments previously discussed in Section VI.B above, Patent Owner does not contest these additional arguments by Petitioner concerning claims 1, 7, 15, and 17. Having considered the arguments and evidence of record, we conclude that Petitioner has demonstrated by a preponderance of the evidence that the combined teachings of Lisogurski, Carlson, and Tran would have disclosed or suggested the limitations of claims 1, 7, 15, and 17 to an ordinarily skilled artisan and that these claims are unpatentable.

4. Claims 2, 10, and 18

Claims 2, 10, and 18 depend from claims 1, 7, and 15, respectively, and recite the wearable device is configured to use artificial intelligence in making decisions associated with (claims 2 and 18) or to process (claim 10) at least a portion of the output signal. Petitioner notes that Tran discloses feeding data from a wearable patient monitoring device such as those disclosed by Lisogurski, to a statistical analyzer, such as Tran's neural network, which is a form of artificial intelligence. *Id.* at 61 (citing Ex. 1064, 3:6–13, 11:6–30, 22:24–30; Ex. 1003 ¶ 218 (Anthony Decl.)). Petitioner further explains that Tran's analysis of patient data can flag potentially dangerous conditions that can be specified as an event or pattern that can harm the patient. *Id.* (citing Ex. 1064, 11:16–19).

Patent Owner does not address the limitations of claims 2, 10, and 18 explicitly. Having considered the arguments and evidence of record, we conclude that Petitioner has demonstrated that the combined teachings of Lisogurski, Carlson and Tran would have disclosed or suggested the limitations of claims 2 and 18 to an ordinarily skilled artisan. We note, however, that claim 10 depends from claim 8 and for other reasons discussed below, we find that Petitioner has not demonstrated that claim 8, and therefore claim 10, is unpatentable. Therefore, we conclude that Petitioner has demonstrated by a preponderance of the evidence only that claims 2 and 18 are unpatentable.

5. Claims 3, 8, and 16

Claims 3 and 16 depend from claims 2 and 15, respectively. Claim 3 recites "the wearable device is at least in part configured to identify an object, and to compare a property of at least some of the output signal to a threshold." Claim 16 recites similar language but uses the term "detect," i.e. claim 16 recites "the wearable device is at least in part configured to detect an object, and a property of at least some of the output signal is compared to a threshold." In addition to their recitation of "identify" and "detect," claims 3 and 16 differ in another way. Claim 3 explicitly recites that the wearable device is configured to identify the object and compare a property of the output signal to a threshold. In contrast, claim 16 recites that wearable device is configured to detect an object and that a property of the output signal "is compared to a threshold." Although both claims 3 and 16 depend from claims that recite the wearable device incudes a "detection system," unlike claim 3, claim 16 does not limit the comparison of the output signal to a threshold to be performed by the wearable device.

Claim 8 depends from claim 7 and recites that "the wearable device is at least in part configured to identify an object, and a property of at least some of the output is compared by at least one of the wearable device, smartphone or tablet to a threshold." Claim 8 is different from both claims 3 and 16. Like claim 3, claim 8 recites that the wearable device is configured to identify an object, but unlike claims 3 and 16, claim 8 recites that the comparison of the output signal property is performed by any one of the wearable device, a smartphone, or a tablet.

Petitioner argues that Lisogurski discloses the device can identify an object, such as an ear or a wrist, because it can distinguish when it has fallen off (probe off error). Pet. 62 (citing Ex. 1011, 36:66–37:2 (stating that the system can detect a system error in the form of a physiologically impossible value, a probe-off error, or other suitable signals)); Ex. 1003, Anthony Decl. ¶ 221. Petitioner further cites Lisogurski as disclosing comparing a detected signal to a threshold or target value and using the outcome to change the operational mode of the device. *Id.* at 63 (citing Ex. 1011, 24:41–57). Petitioner points out that Lisogurski compares the output signal to thresholds that identify portions of interest for further processing or to change light source modulation, e.g., by comparing changes in ambient light and noise to a threshold to determine changes in noise level. *Id.* (citing Ex. 1011, 9:46–52, 37:8–14; Ex. 1003 ¶ 222 (Anthony Decl.)).

Patent Owner contends that Petitioner ignores the distinction between "detect an object" and "identify and object," a distinction that we recognize. PO Resp. 36; *see* Section V, Claim Construction, herein. Referring to Lisogurski's probe off error, Patent Owner contends that "Lisogurski's ability to detect the ***absence*** of a probe does not satisfy either Claim 16's *detection* requirement nor Claims 3 and 8's *identification* requirement." PO Resp. 36.

We have construed the recitation "detect an object" to mean "to discover or notice the existence or presence of something." *See* Section V.B *supra*. As to the detection requirement of claim 16, Patent Owner asserts that Lisogurski teaches only a "probe-off" error signal and that Petitioner fails to explain why a person of ordinary skill would reconfigure Lisogurski's system error signal to discover or notice the presence of a probe. PO Resp. 36 (citing Ex. 1011, 36:66–37:2; Ex. 2136, MacFarlane Decl. ¶ 137). Petitioner responds that Lisogurski's disclosure of generating a probe off signal when the sensor falls off the subject, necessarily implies that the system recognizes the presence of an object, as there is no error indication if an object is present. Pet. Reply 22. To that extent, we agree with Petitioner that Lisogurski discloses that the wearable device is configured to detect an object, as recited in claim 16.

Petitioner further argues that Lisogurski meets the limitation that the wearable device is configured to "identify an object" because Lisogurski and Tran each teach techniques for measuring blood oxygen saturation and other blood constituents. Pet. Reply 24 (citing Pet. 58, 63). Patent Owner contends that this is a new argument improperly raised in the Reply and that, even if properly raised, "measuring" blood constituents is not the same as "identifying." PO Sur-reply 27–28.

We have construed the recitation "identify an object," as recited in claims 3 and 8 to mean "to recognize or establish an object as being a particular thing." *See* Section V.B *supra*. Although blood constituents would appear to be objects in the context of claims 3 and 8, and it is not clear how one could measure such constituents without identifying them, we agree with Patent Owner that the Petition does not sufficiently articulate support for Petitioner's assertions. The Petition states that "[t]he monitored health information includes pulse oximetry measurements," and refers to "Tran's statistical analyzers" as assisting in tracking patient risk. Pet. 58. In addition to its probe-off error analysis, the Petition's discussion of claims 3, 8, and 16 states that blood oxygen may be compared to a threshold or target value, that Lisogurski compares the output signal to thresholds that identify portions of the signal that may be of interest for further processing, and that Tran's data analysis technique allows the user to provide parameters for alert generation. Pet. 63. Petitioner's arguments, which concern comparing detected *signals* to a variety of thresholds and providing *parameters for alert generation*, are insufficient to support Petitioner's contention that Lisogurski, Carlson, and Tran disclose the limitation in claims 3 and 8 that the wearable device (claim 3) or the wearable device, smartphone or tablet (claim 8) is configured to "identify an object" i.e., "to recognize or establish an object as being a particular thing."

6. Claim 9

Claim 9 depends from claim 8 and further recites "a detector output from at least one of the plurality of spatially separated detectors is coupled to an amplifier having a gain configured to improve detection sensitivity." In support of its argument that Lisogurski discloses the additional limitation recited in claim 9, Petitioner cites its arguments concerning claim limitation 1(g). Pet. 57–58 (citing *id.* at 38–39); *see also id.* at 39–40 (discussion of claim limitation 1(h)).

Having determined that Petitioner has not presented sufficient arguments to support its challenge to claim 8, we reach the same conclusion as to claim 9, which depends from claim 8.

7. Claims 4, 11, 12, 19, 21, and 22

Claim 4 depends from claim 3, claims 11 and 12 depend indirectly from claim 8. Having determined that Petitioner has not presented sufficient arguments to support its challenge to claims 3 and 8, from which claims 4, 11, and 12 depends, we conclude that Petitioner has not established that claims 4, 11, and 12 are unpatentable under this ground.

Claim 19 depends from claim 18 and recites that the artificial intelligence includes pattern identification or classification and a pattern matching algorithm. Petitioner cites Tran as disclosing neural networks are used to recognize patterns. Pet. 64 (citing Ex. 1064, 23:39–50). Claim 21 depend from claim 15 and recites "the wearable device is configured to perform pattern identification or classification based on at least a part of the output signal." Similarly, claim 22 depends from claim 21 and recites the pattern identification or classification comprises a pattern matching algorithm. According to Petitioner, Tran uses neural networks to track and flag patterns in a patient's vital signs to recognize possibly dangerous conditions. *Id.* at 63–64 (citing Ex. 1064, 22:23–59, 23:4–16; Ex. 1003 ¶ 227 (Anthony Decl.)). Petitioner further notes that Tran teaches using the neural network with a Hidden Markov Model (a derived set of reference pattern templates) to perform pattern matching and pattern identification or classification. *Id.* at 64–65 (citing Ex. 1064, 24:45–60, 80:24–81:3; Ex. 1003 ¶ 227 (Anthony Decl.)).

Patent Owner does not present any contrary evidence or arguments concerning Petitioner's challenge to claims 19, 21, and 22. Having considered the arguments and evidence of record, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claims 19, 21, and 22 are unpatentable.

8. Claim 20

Claim 20 depends from claim 18 and recites "the artificial intelligence comprises spectral fingerprinting." Petitioner cites Tran as disclosing its neural networks analyze blood oxygen saturation by measuring the ratio of oxygenated to unoxygenated hemoglobin in blood. Pet. 65 (citing Ex. 1064, 11:1–8, 36:61–37:13, 52:31–35; Ex. 1003 ¶ 231). Petitioner notes that Tran further discloses using "a form of spectral fingerprinting by measuring the blood's absorbance or reflectance of different wavelengths of light to determine how much oxygenated hemoglobin and unoxygenated hemoglobin is present." *Id.* (citing Ex. 1064, 37:2–13, 50:10–15).

Patent Owner does not present any contrary evidence or arguments concerning Petitioner's challenge to claim 20. Having considered the arguments and evidence of record, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claim 20 is unpatentable.

9. Conclusion

For the reasons discussed above, we find that Petition has demonstrated by a preponderance of the evidence that independent claims 1, 7, and 15 and dependent claims 2 and 16–21 are unpatentable over the teachings of Lisogurski, Carlson, and Tran. We further find that Petitioner has not demonstrated that claims 3, 4, and 8–12 are unpatentable on this ground.

D. Claims 5 and 13 As Obvious Over Lisogurski, Carlson, Tran, and Isaacson

Petitioner notes that claims 5 and 13 further limit claims 4 and 12, respectively, and recite spacing requirements for LEDs and photodetectors. Pet. 66. Petitioner cites Isaacson as teaching the additional limitations recited in claims 5 and 13. *Id.* Claims 5 and 13 indirectly depend from claim 3 and 8, respectively, and incorporate all the limitations therein.

Petitioner cites Isaacson as disclosing a pulse oximetry system sensor for use on a patient's arm and that has two emitters and two detectors separated by varying distances. Pet. 66 (citing Ex. 1063, 1:21–40, 2:57–58, 2:63–66, 3:66–4:3, 3:44–54, 6:32–34). Petitioner notes that Isaacson teaches selecting the distances between the emitters and detectors to allow measuring light that has penetrated different depths of tissue, with greater spacing allowing measuring of greater depth. *Id.* (citing Ex. 1063, 1:41–45, 5:10–15; Ex. 1003 ¶¶ 234–235 (Anthony Decl.)).

As discussed above, we conclude that Petitioner has not demonstrated that the combined teaching of Lisogurski, Carlson and Tran teach the limitations of claims 3 and 8. Petitioner does not assert that Isaacson teaches the limitations of claims 3 and 8 from which claims 5 and 13 indirectly depend. Therefore, we conclude that Petitioner has not demonstrated that claims 5 and 13 are unpatentable over Lisogurski, Carlson, Tran and Isaacson.

E. Claims 6, 14, and 23 As Obvious Over Lisogurski, Carlson, Tran, Isaacson, and Valencell-093

1. Valencell-093

Valencell-093 describes a wearable monitoring apparatus, with a sensor module "includ[ing] an energy emitter that directs energy at a target region of the subject" and a detector that detects an energy response signal or physiological condition from the subject. Ex. 1005, code (57), ¶ 5. The wearable apparatus may be an earbud or earpiece, a wristband, armband, or headband, among others. *Id*. ¶¶ 6, 50, 110, 151, Figs. 4A, 4B, 23. Valencell-093 describes that physiological conditions that may be detected, including heart rate, blood pressure, and blood constituent data such as blood oxygen level. *Id*. ¶¶ 6, 50, 109.

Figures 4A and 4B of Valencell-093, reproduced side-by-side below, show a side view (Figure 4A on the left) and front view (Figure 4B on the right) of a human ear with an earbud monitor according to one embodiment of the invention. *Id*. ¶¶ 57, 58.

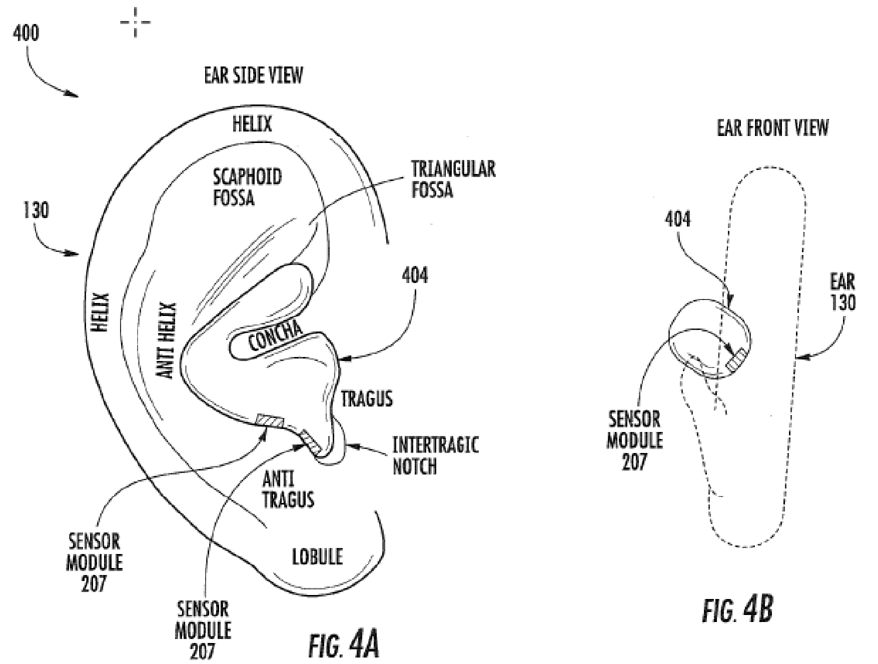

FIG. 4A FIG. 4B

Figures 4A and 4B show ear 130 with biometric audio earbud 404 including sensor modules 207. *Id.* ¶ 110.

Sensor module 207 of Valencell-093 is illustrated in Figure 2, reproduced below. *Id.* ¶¶ 54, 109.

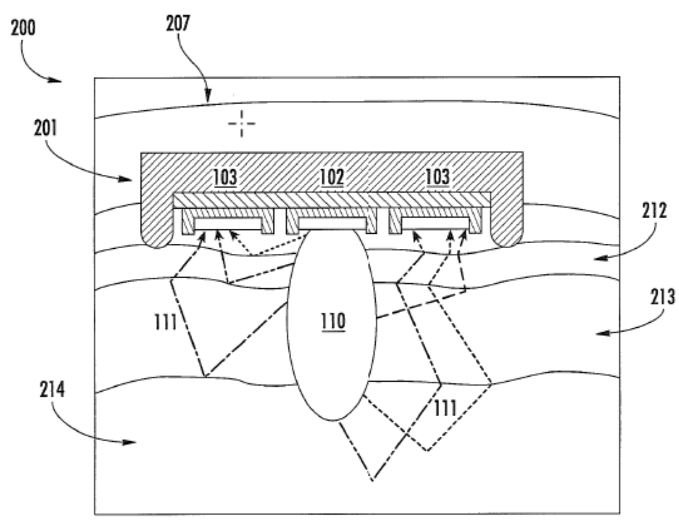

FIG. 2

Figure 2 illustrates sensor module 207, which includes optical emitter 102 and optical detectors 103. Emitter 102 generates one or more optical wavelengths 110, producing scattered optical energy 111, which is modulated by changes in the skin tissue (epidermis 212, dermis 213, and subcutaneous layers of skin tissue 214), and thus may contain information associated with a physiological condition of the subject. *Id.* ¶ 109.

Figure 7 of Valencell-093, reproduced below, depicts a sensor module configuration according to some embodiments of Valencell-093. *Id.* ¶ 60.

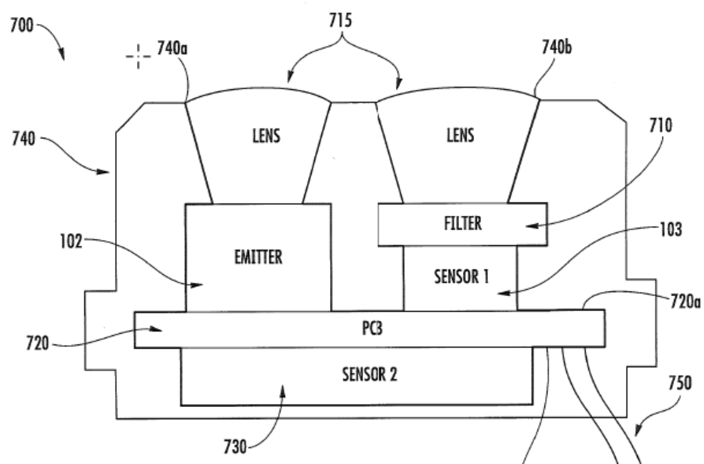

FIG. 7

Figure 7 shows a sensor with over-molded design that includes sensor lenses 715, respectively covering emitter 102 and sensor 103, which are used "[t]o guide light from the optical emitter 102 towards the skin 130 of a subject and to direct light from the skin 130 to the optical detector 103." *Id.* ¶¶ 116, 118. In the embodiment shown in Figure 7, the emitter and sensor lenses 715 are physically separate. *Id.* ¶ 118. In such cases, Valencell-093 teaches that the lenses "may be isolated by at least one light opaque barrier region greater than 50 μm in thickness," which may be metal. *Id.* Filter 710 "may serve as both an optical wavelength filter and an attenuation filter" to block unwanted sunlight but still allow wavelengths from the optical emitter to be received at sensor 103 in the form of attenuated optical scatter 111. *Id.* ¶¶ 117, 123. "To offset this unwanted reduction in optical scatter 111, the intensity of the optical emitter 102 may be increased to increase the ratio of physiological optical scatter 111 from blood vessels with respect to unwanted sunlight." *Id*. ¶ 123. Because there may be environmental interference from, e.g., "sunlight, ambient light, airflow, [or] temperature" the monitoring apparatus of Valencell-093 may obtain an "optical interaction response" at the detector (sensor 103) when the pulsed optical energy 110 is produced, and a second response when the pulsed optical energy is in an off state. *Id*. ¶ 108. These two signals are used to remove the environmental interference and generate an accurate physiological signal. *Id*.

2. Reason to Combine

Petitioner notes that Lisogurski, Carlson, Tran, and Valencell-093 are analogous systems with common applications and utility. Pet. 74. Petitioner asserts that a person of ordinary skill would have been motivated to combine the teachings of Lisogurski with those of Valencell-093 because they both concern analogous miniaturized pulse oximetry devices having the same applications. *Id.* at 73. Petitioner notes that Lisogurski teaches several techniques for improving signal-to-noise ratio of measured signals in a wearable sensor, while minimizing power consumption. *Id.* (citing Ex.1011, 1:4–6, 1:16–18, 3:50–53, 4:15–2, 4:63–67, 9:46–52, 17:51–58). Petitioner further notes that Valencell-093 seeks to achieve similar objectives by configuring an optical sensor to maximize coupling and minimize relative motion between the user's skin and a wearable device, e.g., by using light guides positioned to focus on the blood flow and reduce the effect of environmental noise. *Id.* at 74 (citing Ex. 1005 ¶ 153).

Patent Owner acknowledges that Petitioner has asserted reasons to combine the teachings of Valencell-093 and Lisogurski, but contends that Petitioner has not described a reason for combing the teachings of all the references in this ground. PO Resp. 40–43. Petitioner responds that it proposes a person of ordinary skill would have had reason to incorporate Valencell-093's reflective surface into Lisogurski to improve optical coupling and relative motion between the wearable device and the user's skin, thereby furthering Lisogurski's goal of improving signal-to-noise ratio. Pet. Reply 26.

We agree that Petitioner was not required to show why a skilled person would have considered every permutation of the references. *Id.* Petitioner has demonstrated that Valencell-093 is relevant to the subject matter that Petitioner relies on it to disclose in the context of wearable devices. We conclude Petitioner has demonstrated sufficiently that a person of ordinary skill would have had reason to combine the teachings of Lisogurski and Valencell-093.

3. Claims 6, 14, and 23

Claims 6 and 14 indirectly depend from claims 3 and 8 and therefore recite all the limitations therein. Petitioner does not assert that Valencell-093 teaches the limitations of claims 3 and 8 from which claims 6 and 14 indirectly depend. Therefore, we conclude that Petitioner has not demonstrated that claims 6 and 14 are unpatentable over Lisogurski, Carlson, Tran, Isaacson, and Valencell-093. As Petitioner cited Isaacson for its teaching concerning the limitations of claim 5 and 15 from which claims 6 and 14 depend, we do not consider Isaacson further in this ground.

Claim 23 depends from 15 and recites "a reflective surface positioned to reflect at least a portion of [the lens output] light reflected from the tissue." Petitioner cites Valencell-093 as teaching that a sensor can be surrounded by a light guiding region to direct light to and from a sensor module and that the light guiding regions can include a reflector, such as a metal or alloy. Pet. 75–76 (citing Ex. 1005 ¶ 152, Figs. 24, 26, 27). As a further basis for combining the teachings of Valencell-093 with those of Lisogurski, Petitioner further notes that Valencell-093 explains that using such a reflective surface increases signal-to-noise ratio. *Id.* at 76 (citing Ex. 1005 ¶ 153).

Patent Owner does not contest Petitioner's evidence or arguments concerning the substance of Valencell-093. Having reviewed the evidence and arguments of record, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claim 23 is unpatentable over the combined teachings of Lisogurski, Carlson, Tran, and Valencell-093.

VII. CONCLUSION[12]

Having reviewed the evidence and arguments of record, we conclude that Petitioner has demonstrated by a preponderance of the evidence that claims 1, 2, 7, and 15–23 are unpatentable. Petitioner has not demonstrated that claims 3–6, and 8–14 are unpatentable.

[12] Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding. See* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. § 42.8(a)(3), (b)(2).

In summary:

Claims	35 U.S.C. §	Basis	Claims Shown Unpatentable	Claims Not shown Unpatentable
1, 7, 15, 17	103	Lisogurski, Carlson	1, 7, 15, 17	
1–4, 7–17, 15–22	103	Lisogurski, Carlson, Tran	1, 2, 7, 15–22	3, 4, 8–12
5, 13	103	Lisogurski, Carlson, Tran, Isaacson		5, 13
6, 14, 23	103	Lisogurski, Carlson, Tran, Isaacson, Valencell-093	23	6, 14
Overall Outcome			1, 2, 7, 15–23	3–6, 8–14

VIII. ORDER

In consideration of the above it is:

ORDERED that claims 1, 2, 7, and 15–23 are unpatentable;

FURTHER ORDERED that claim 3–6 and 8–14 have not been shown to be unpatentable; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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