

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HESAI TECHNOLOGY CO., LTD.
Petitioner

v.

OUSTER, INC.
Patent Owner

Case No. IPR2023-01421
U.S. Patent No. 11,175,405

PATENT OWNER RESPONSE UNDER 37 C.F.R. § 42.120

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EXHIBIT LIST

EXH. NO.	DESCRIPTION
2001	Respondent's Proposed Claim Construction dated June 28, 2023, filed in ITC Inv. No. 337-TA-1363
2002	Respondent's Proposed List of <i>Markman</i> Exhibits dated July 13, 2023, filed in ITC Inv. No. 337-TA-1363
2003	Excerpts from <i>Fluorescence Microscopy, Principles to Biological Apps</i> (2d ed. 2017)
2004	Excerpts from Merriam-Webster's Collegiate Dictionary (11th ed. 2014)
2005	Respondent's Proposed List of Terms to be Construed dated June 21, 2023, filed in ITC Inv. No. 337-TA-1363
2006	Excerpts from Rudolf F. Graf, <i>Modern Dictionary of Electronics</i> (7th ed. 1999)
2007	Excerpts from Frank Pedrotti, <i>Introduction to Optics</i> (3d ed. 2006)
2008	Biography of Patrick W. Lauppe
2009	Declaration of Patrick W. Lauppe ISO Motion for <i>Pro Hac Vice</i> Admission
2010	Declaration of Jason A. Janét, Ph.D.
2011	Transcript of James F. Shanley, Ph.D., deposition dated June 6, 2024
2012	U.S. Patent No. 7,969,558, to David S. Hall
2013	Warren J. Smith, <i>Practical Optical System Layout and Use of Stock Lenses</i> (1997)
2014	Sergey L. Vinogradov, "Evaluation of performance of silicon photomultipliers in LIDAR applications" (2017)

EXH. NO.	DESCRIPTION
2015	Edoardo Charbon et al, “SPAD-Based Sensors” (2013)
2016	Cristiano Niclass, et al, “A Single Photon Avalanche Diode Array Fabricated in Deep-Submicron CMOS Technology” (2006)

The Board should find claims 21 and 23-34 (the “challenged claims”) of U.S. Patent No. 11,175,405 (the “’405 patent”) patentable over the instituted grounds.

I. INTRODUCTION

The ’405 patent represents Ouster’s innovative approach to LIDAR that has transformed the industry and led to the widespread success and adoption of Ouster’s sensors and technology. Ouster relies upon emitters and sensors previously disfavored in the industry for high-noise, demanding LIDAR applications. These include the relatively lower power (and hence, weaker signal) VCSEL laser emitters and the sensitive but unreliable and noisy single-photon avalanche diode (“SPAD”) sensors. To build a system upon these components, the Ouster inventors had to develop a new optical scheme including optics, apertures, and optical filters. The result was cheap, efficient, and highly sensitive LIDAR devices. Using the hindsight of a LIDAR industry shaped by Ouster’s own contributions, Hesai now attacks the ’405 patent by advancing unsupportably broad claim interpretations and bolting together references that no POSITA would have considered combinable—particularly without the hindsight guidance of Ouster’s innovations including the ’405 patent claims themselves. Hesai’s obviousness grounds must fail—the Board should find the challenged claims of the ’405 patent patentable over the instituted grounds.

Hesai attacks the challenged claims of the '405 patent using two main obviousness combinations—Pacala-Droz and Hall-Borowski-Spector. The Pacala-Droz combination—the basis for Hesai's grounds 1 and 2—combines “waveguides” from Droz with the spinning LIDAR system of Pacala in an attempt to satisfy the claimed requirement of “an aperture layer comprising a plurality of apertures separated by a stop region.” But Hesai's theory of how Droz's waveguides satisfy this claim limitation is predicated on an erroneous and unsupportable construction of “stop region.” The intrinsic and extrinsic evidence clearly demonstrates that a POSITA would have considered a “stop region” to be an optical term of art indicating an optically non-transparent region that defines a field of view (for a photosensor in the context of the '405 patent). But Hesai and its expert ignore the intrinsic and extrinsic evidence and instead assert, without evidence, that a stop region is nothing more than a region that stops light from propagating in an area. Since Hesai's Pacala-Droz combination can only satisfy the “stop region” limitation if Hesai's overbroad and unsupportable construction is adopted, the challenged claims must be found patentable over the Pacala-Droz combination.

Additionally, the Pacala-Droz combination is based on piecing together a system from incompatible design elements without any regard for what a POSITA would have considered to be the demands of a workable system. The Pacala-Droz combination requires bolting together two facially incompatible design features—

Droz's waveguides—stacks of solid materials adapted for a stationary imaging system—with Pacala's rotating LIDAR system. Confirming the ill-fitting nature of these systems, Hesai's expert could not testify to nearly any aspect of the combined system. He was unaware of the weight, size, mass distribution, or rotational forces—and he said that the process of combining these systems would require an entire team of engineers working for an unspecified amount of time, potentially up to one man year of labor. Hesai and its expert's lack of regard for what would have truly been obvious or even remotely practical in the eyes of a POSITA betray the hindsight-driven approach they have taken to this IPR. Accordingly, the Pacala-Droz combination must fail due to lack of obviousness—separate and apart from Hesai and its expert's failure to plausibly account for the “stop region” limitation in this combination.

The Hall-Borowski-Spector combination—the basis for Hesai's remaining grounds 3 and 4—fares no better. Hesai and its expert rely upon Spector's emitter and aperture arrays. Spector teaches that these arrays must be horizontally and vertically scanned over the detection area and its periphery to fill in the holes between detection areas. Hesai and its expert ignore Spector's teachings and instead seek to bolt Spector's emitter and aperture arrays onto Hall's rotating LIDAR system without the horizontal and vertical scanning Spector indicates is essential for its arrays to function. A POSITA would not have ignored Spector's teachings, and

based on those teachings, a POSITA would not have considered combining Spector's emitter and aperture arrays with Hall's rotating LIDAR system. Accordingly, Hesai cannot prevail on the Hall-Borowski-Spector combination.

The Hall-Borowski-Spector combination must also fail due to the lack of a motivation to combine Borowski and Spector. In the Hall-Borowski-Spector combination, Hesai asserts that it would have been obvious to incorporate Borowski's SPAD arrays and Spector's aperture arrays. However, Spector teaches that for low fill factor detectors (*i.e.*, detectors that have a small ratio of detector size to space between detectors), apertures are unnecessary. Since a POSITA would have understood that SPAD arrays are low fill factor detectors (with no reasonable expectation of success for increasing their fill factor), a POSITA would have had no motivation to combine Borowski's SPAD arrays with Spector's aperture arrays.

Moreover, the Hall-Borowski-Spector combination must fail because of a lack of a motivation to combine Hall and Borowski. Hall's system—a rotating LIDAR system adapted for noisy environments like the top of an autonomous vehicle on a busy street—is based around avalanche photodiodes, or APDs. Hesai and its expert swap out Hall's APDs for Borowski's SPAD arrays. The overwhelming evidence—including Hesai's expert's own declaration and testimony—indicates that a POSITA would have considered SPADs to be an unacceptable replacement for APDs in a noisy system like Hall's. And yet Hesai and its expert provide *no* motivation to swap

out Hall's APDs for the noisier SPAD arrays. Further, Hesai and its expert provide *no* indication of how a POSITA would have accounted for the issues with SPADs in Hall's noisy system. In fact, Hesai and its expert do not even acknowledge that APDs are disclosed by Hall—instead, acting as if Hall disclosed that it could be used with any photodetector under the sun. Accordingly, the Hall-Borowski-Spector combination must further fail because a POSITA would not have considered Hall and Borowski to be combinable.

The inadequacy of Hesai and its expert's obviousness combinations is confirmed by clear evidence in support of secondary considerations of nonobviousness. For example, the testimony of Hesai's expert provides strong support for the skepticism of the industry toward SPAD-based approaches to LIDAR represented by the '405 patent claims. Hesai's expert testified that though he was aware of SPADs as early as the 1990s, he never used SPADs in any of the various LIDAR systems he subsequently worked on because of concerns about their volume, power requirements, reliability, complexity, lack of availability, and difficulty of use. Further, Hesai's expert could not identify a single LIDAR system—commercial or otherwise—prior to the '405 patent that used SPADs. In addition to industry skepticism, there is clear evidence of the failure of others in support of the nonobviousness of the '405 patent claims. Publications from around the May 15, 2017 priority date of the '405 patent indicate that many had tried but all had failed

to develop workable SPAD arrays for a LIDAR system prior to the '405 patent.

The Board should find claims 21 or 23-34 of the '405 patent patentable over the instituted grounds.

II. BACKGROUND

A. Level of Ordinary Skill in the Art

Patent Owner submits that a POSITA would have had an undergraduate degree in mechanical or electrical engineering and two to three years of work experience with electro-optical and electro-mechanical devices or systems, with, at a minimum, at least one year of work experience was with LIDAR designs, where less work experience may be compensated by a higher level of education or vice versa. (EX2010, ¶¶60-62.)

Petitioner asserts that a POSITA would have had more years in LIDAR design. (Pet. at 12.) Petitioner's expert also testified that a POSITA would have been a *team* of engineers, including an optical engineer, an electrical engineer, and a mechanical engineer. (*Id.*, 57:11-58:1, 57:3-58:21.) These stringent requirements on a POSITA's level of experience appear to be Petitioner and its expert's attempt to shore up the incompatible obviousness combinations on which the petition relies, as outlined below. Accordingly, Patent Owner submits that Patent Owner's POSITA definition should be adopted. (EX2010, ¶62.)

B. Specification Overview

The '405 patent sought to improve narrowband imagers that “collect[] light

within a limited wavelength range.” (EX1001, 1:34-35.) The ’405 patent discloses that “[c]urrent narrowband imagers have either a small field-of-view or are limited in their ability to filter wavelength bands narrower than around 50 nm.” (*Id.*, 1:51-53.) “Optical filters are sensitive to the angle of incident light,” but “[c]onstricting the angle of light incident upon the photodetector usually requires using a lens with a longer focal length, which constricts the field-of-view[.]” (*Id.*, 1:53-64.) One application of narrowband imagers is LIDAR systems, for which “it is beneficial for physical sizes of transmitters and receivers to [be] small and compact, and at the same time relatively low in cost.” (*Id.*, 2:29-31.) The ’405 patent discloses that micro-optical systems can be used for LIDAR, but “[m]icro-optical receivers arrayed adjacent to each other are susceptible to cross-talk.” (*Id.*, 2:39-41.)

The ’405 patent discloses embodiments of “wide field-of-view, narrowband imaging with micro-optic receiver channel arrays that minimize cross-talk and allow tight spectral selectivity that is uniform across the receiver channel array.” (*Id.*, 2:63-67.) One exemplary embodiment is shown in Figure 2 of the ’405 patent:

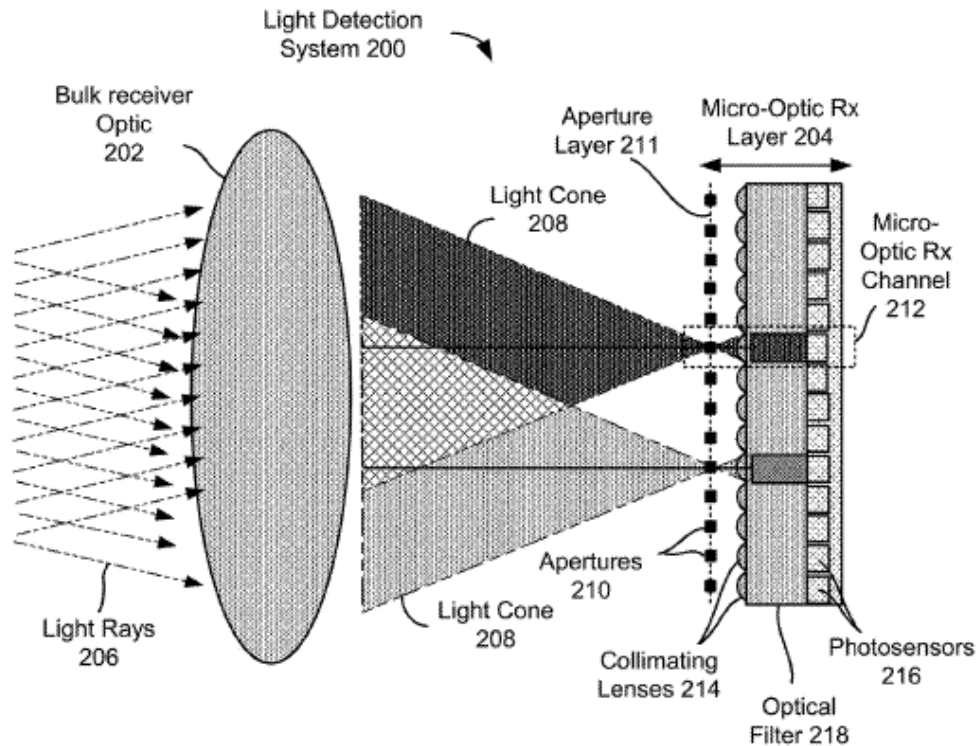


FIG. 2

(*Id.*, Fig. 2.) Light rays enter the system through bulk receiver optic **202** and are focused to form light cones **208**. (*Id.*, 13:39-42.) The light cones pass through apertures **210** in aperture layer **211**, enter collimating lenses **214**, and pass through optical filter **218** to reach photosensors **216**. (*Id.*, 13:42-50, 14:10-28.)

Several embodiments include VCSELs and SPADs as the emitters and detectors, respectively. (*Id.*, Figs. 8, 11, 5:64-6:10, 6:62-7:12, 21:48-58, 28:59-29:3.) The '405 patent indicates that the use of VCSELs and SPADs comes with advantages, including that it

enables multiple measurements to be taken at the same time (i.e., the VCSEL emitters can be fired

simultaneously) and also enables the set of emitters and the set of photosensors to each be fabricated using standard CMOS processes on a single chip, greatly simplifying the manufacturing and assembly process.

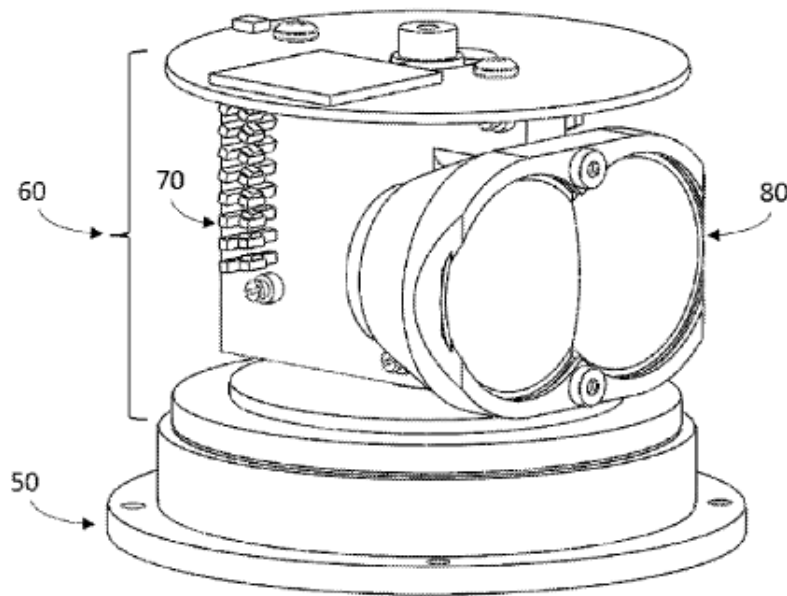
(*Id.*, 28:6-11.) Further, the '405 patent indicates that the use of VCSELs and SPADs has various disadvantages, which are addressed by the optical elements like those shown in Figure 2. (*Id.*, 28:12-27 (“[A]s discussed herein with respect to FIG. 2, a light detection system **200** can include a micro-optic receiver layer **204** for enhancing the light detected by photosensors **216**, e.g., SPADs.”).)

III. PETITIONER’S ASSERTED PRIOR ART

A. Pacala (EX1004)

U.S. Patent Publication No. 2014/0211194 A1 (“Pacala”; EX1004) is a high-level description of a rotating LIDAR sensor that “contains a motor and distributed electronics, and a spinning turret **60** that contains optoelectronic component **70** (including optical transmitters and receivers), collimation and focusing lenses **80** and distributed electronics.” (EX1004, [0013].) Pacala was abandoned during prosecution.

The sensor is shown in Pacala’s Figure 2:



(EX1004, Fig. 2.) Most of the remaining description of Pacala is dedicated to discussing signal processing circuits, with the final sentence stating: “The multi-channel TDC electronic circuitry with multiple voltage thresholds can be implemented with discrete integrated circuits (ICs), in the form of FPGA logic, as part of an application-specific integrated circuit (ASIC), or integrated into the pixels of a detector array (e.g., Single-Photon Avalanche Diode [SPAD] array).” (*Id.*, [0014].) This parenthetical is the only disclosure of single-photon avalanche diodes, or SPADs, in Pacala. EX2011 (Shanley depo transcript), 44:16-45:2 (“Q. And so you said that Pacala’s teaching of the use of SPADs comes at the end of Paragraph 14. Is there any other teaching of SPADs in Pacala, Exhibit 1004? A. No.”)

B. Droz (EX1006)

U.S. Patent 10,605,984 (“Droz”; EX1006) discloses systems for light detection. One embodiment disclosed by Droz is shown in Figure 3B:

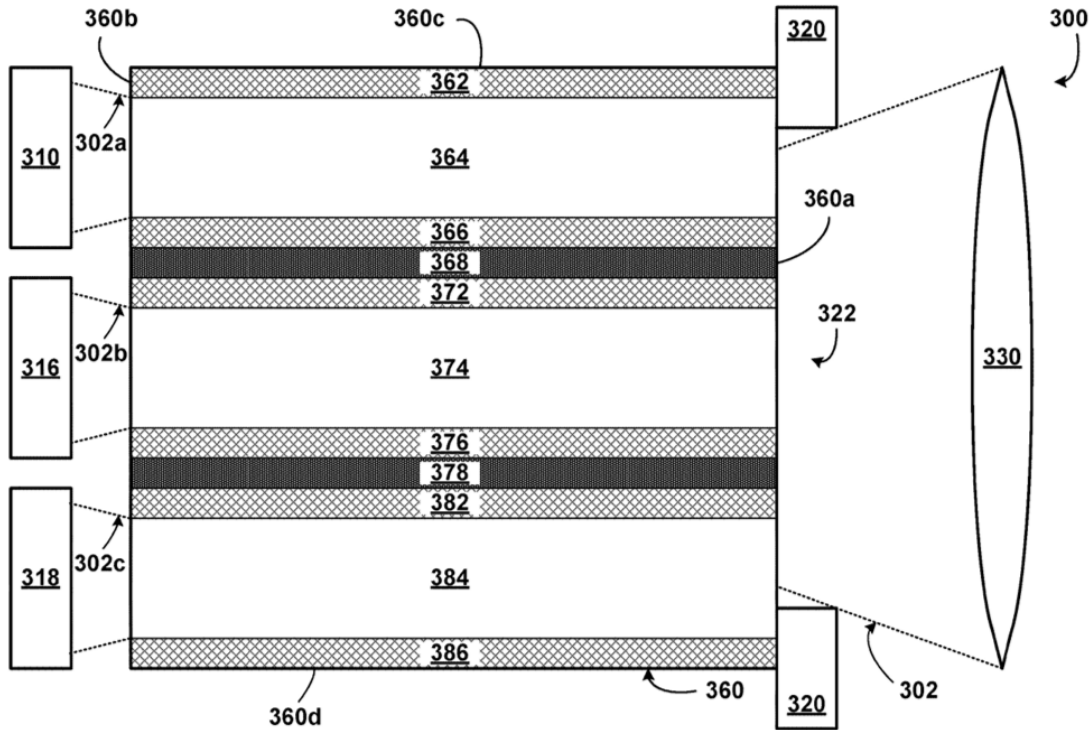


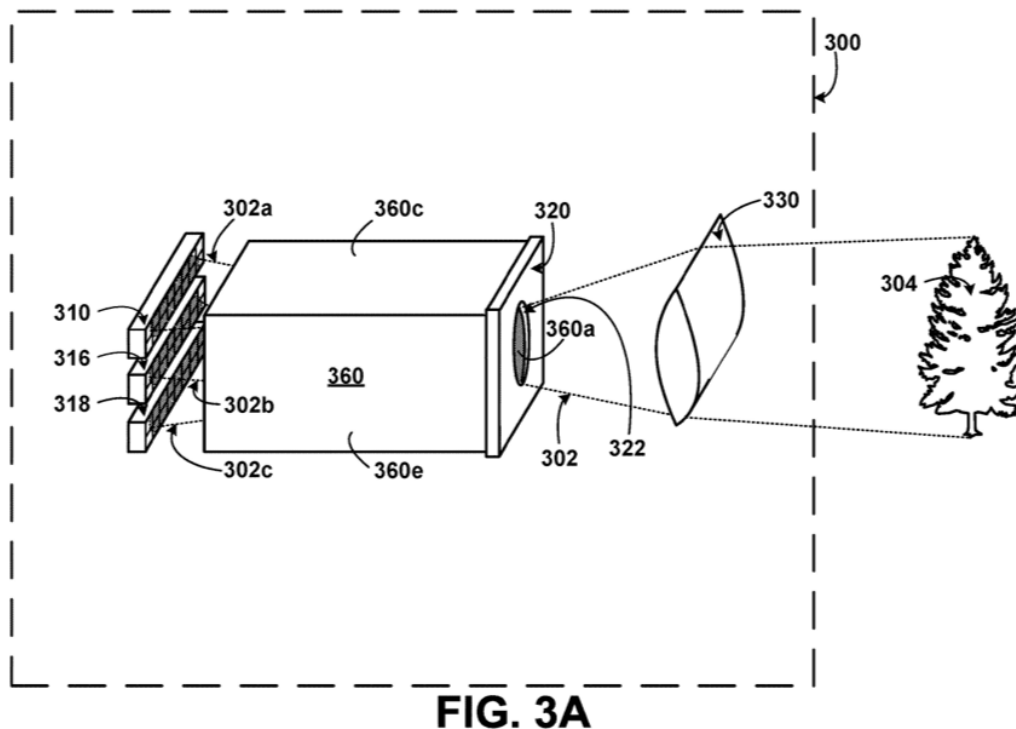
FIG. 3B

(EX1006, Fig. 3B.) Light from lens **330** is directed to waveguide array **360**. (*Id.*, 13:20-22.) Each waveguide is made up of several layers of solid material. (*Id.*, 13:28-43.) First, each waveguide consists of one of three “core layers” **364**, **374**, and **384**. These core layers are made up of “a relatively high index of refraction material, such as a glass or high-index polymer substrate for instance, that is transparent to at least some wavelengths of light **302**.” (*Id.*, 13:34-37; *see also id.*, 4:29-39, 13:44-54, 16:31-39, 19:21-26.) Second, each waveguide consists of “cladding layers” **362**, **366**, **372**, **376**, **382**, and **386**, which “may comprise a relatively low index of refraction material, such as polymer coated or fluorine-doped glass substrates for instance.” (*Id.*, 13:31-35; *see also id.*, 13:44-54.) Third, “absorbing layers” **368** and **378** are included in the waveguide array, which “may

comprise an absorber formed from any material suitable for absorbing wavelengths of light **302** guided within waveguide array **360**,” including “carbon black, black chrome, among others.” (*Id.*, 13:39-43.)

Droz discloses that absorbing layers **368** and **378** are included to mitigate the leakage of light from one waveguide to another. Accordingly, absorbing layers have “a suitable thickness to absorb the evanescent field evanescent from the first waveguide and/or second waveguide” or between the second and third waveguides. (EX1006, 14:54-60.)

Droz discloses only static systems that are oriented in a particular direction and detect light from a scene. (EX2010, ¶76.) For example, the system shown in Figure 3A of Droz is stationary:



(EX1006, Fig. 3A.) While Droz discloses an actuator that can move certain components in relation to other components (*e.g.*, moving an emitter relative to detector components), Droz does not disclose any embodiments where all components move together (*e.g.*, on a rotating platform). (*See* EX1006, 5:8-10 (“[A]rray **110** may be actuated closer to, or further from, aperture **122**.”), 11:67-12:3 (“[C]ontroller **250** could change the projection (*e.g.*, pointing) direction of emitter **240** (*e.g.*, by actuating a mechanical stage that mounts emitter **240**).”), 16:1-4 (“[S]ystem **300** may also include an actuator that moves lens **330**, opaque material **320**, and/or array **360** to achieve a particular optical configuration while scanning the scene.”), 16:7-10.)

C. Hall (EX1008)

U.S. Patent No. 9,983,297 (“Hall”; EX1008) discloses “LIDAR based 3-D point cloud measuring systems.” (EX1008, 1:16-17.)

Hall discloses “[a] LIDAR device [that] includes a plurality of pulse illumination sources and corresponding detectors.” (*Id.*, 2:54-56.) Hall discloses that “[i]n some embodiments, a pulsed illumination source and photosensitive detector are mounted to a rotating frame of the LIDAR device.” (*Id.*, 2:59-61.)

Figure 2 of Hall shows an embodiment:

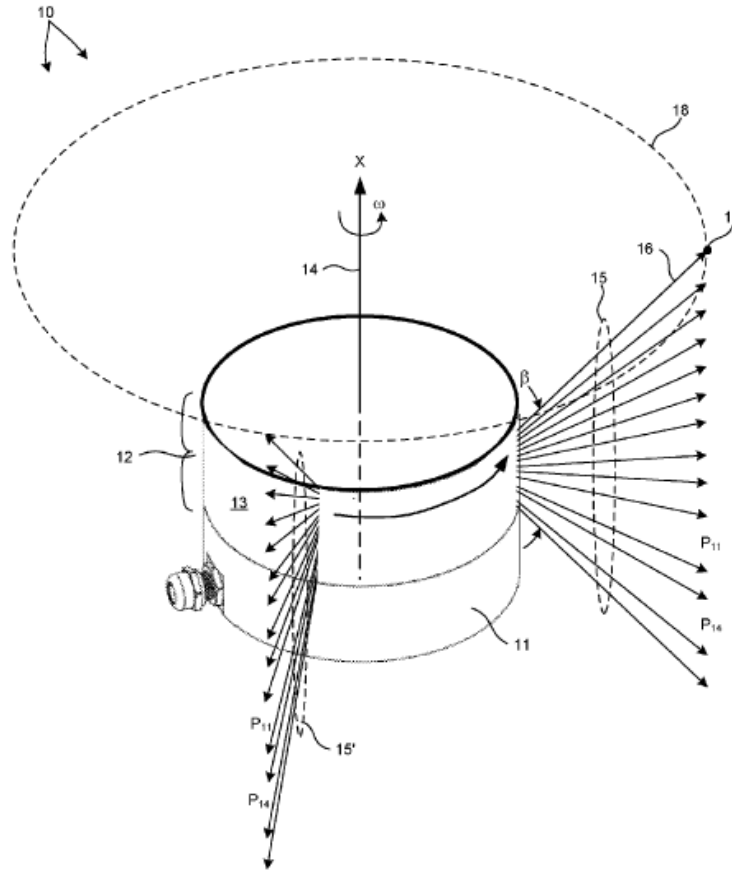


FIG. 2

(*Id.*, Fig. 2.) The embodiment shown in Hall’s Figure 2 includes “a plurality of beams of light **15**” emitted from the system and projected onto the surrounding environment “in a plurality of different directions.” (*Id.*, 5:50-56.) The LIDAR system is “configured to scan each of the plurality of beams of light **15** about central axis **14**.” (*Id.*, 5:64-66.) “As the beams of light **15** rotate about central axis **14**, each beam of light projected into the surrounding environment ... illuminates a volume of the environment corresponding [to] the cone shaped illumination beam as it is swept around central axis **14**.” (*Id.*, 6:4-9.)

Hall incorporates by reference in its entirety U.S. Patent No. 7,969,558 to David S. Hall (“Hall ’558”; EX2012). (EX1008, 2:8-14.) Hall indicates that Hall ’558 discloses “a 3-D LIDAR system . . . that includes an array of multiple laser emitters and detectors.” (*Id.*) Hall ’558 indicates that each of its detectors is a “photo diode [that] is preferably an Avalanche variety, but other types can be used.” (EX2012, 5:5-7; *see also id.*, 5:28-31 (“[T]he detection circuitry consists of high speed A-D’s[.]”).)

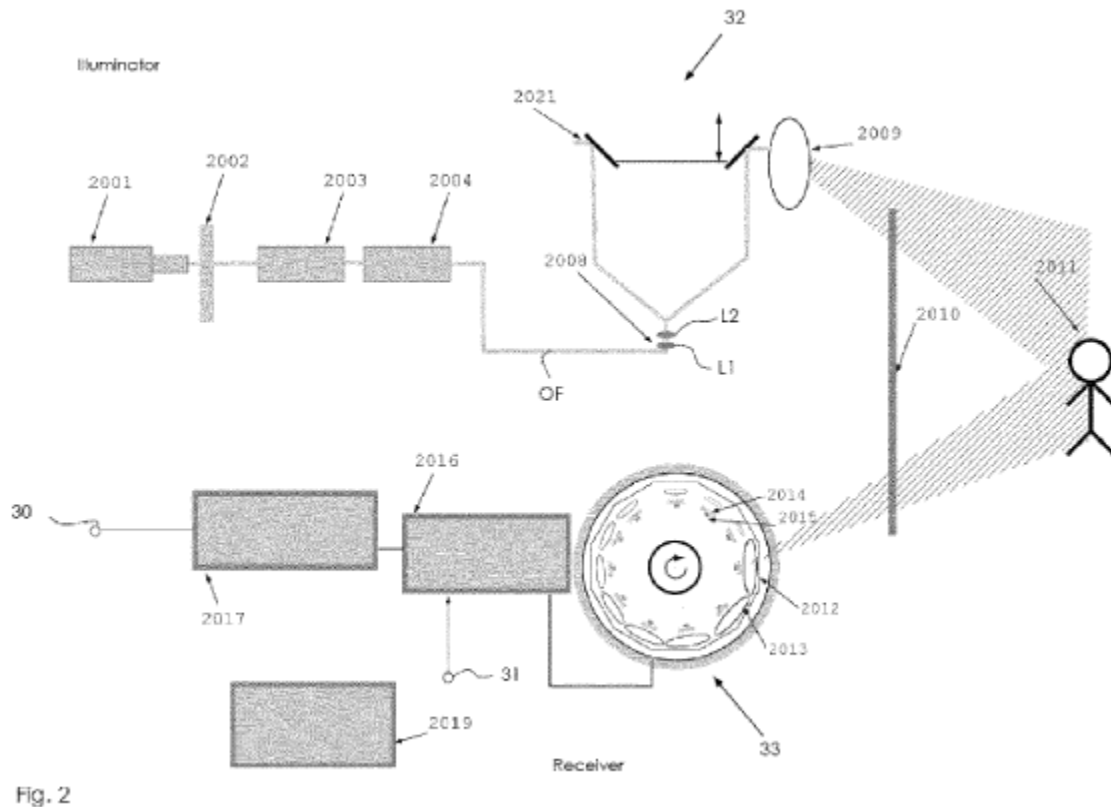
D. Borowski (EX1009)

U.S. Patent Application Publication No. 2013/0300840 A1 (“Borowski”; EX1009) discloses a 3D landscape real-time imager. (EX1009, Abstract.) Borowski’s imager consists of:

an illuminating part which is designed to scan at least a portion of the landscape at a given range and having an ultra-short laser pulse source emitting at least one wavelength, and an optical rotating device, with a vertical axis of rotation, and controlled such that packets of pulses are shaped in a pattern of rotating beams sent toward the said at least partial landscape.

(*Id.*, [0006].) Further, Borowski’s imager consists of a receiver part comprising “an optical rotating device, with a vertical axis of rotation, which carries a set of SPAD (single photon avalanche diode) detector arrays, where the diodes are arranged along the vertical direction, and the optical rotating device of the receiving part is rotating in synchronism with the optical rotating device[.]” (*Id.*, [0007].)

Borowski's embodiments involve optical rotating devices on the illuminating and receiver sides, in which mirrors and lenses are rotated to scan through portions of the environment illuminated and detected by the imager. Figure 2 shows an embodiment of Borowski's imager:



(EX1009, Fig. 2.) The illuminating part of the imager emits light at “several wavelengths around 1.5 μm and at several repetition frequencies in the GHz range.” (*Id.*, [0061].) “[U]ltra-short (1 ps width) laser pulses are emitted in small groups or packets with large (at nanosecond- or tens of nanosecond-level) delay between packets.” (*Id.*, [0065].) “The fast rotating optical device or block **32** with a simple two-lens optical joint **2008** splits unequally the amplified laser beam between the

different emitter groups, each targeting the illuminated scene at a different depth.” (*Id.*, [0067].) “The rotating lens group **2009**, one out of 4 to 12, collimates the beam horizontally and makes it divergent at a particular angle vertically.” (*Id.*, [0068].)

The receiving part of the Figure 2 embodiment “comprises another optical rotating device **33**.” (*Id.*, [0075].) “The receiving part also comprises a rotating block **2012** which comprises multiple (e.g., 12) lenses **2013** adjusted for various focus and size, collecting simultaneously the faint light reflected from targets in several directions.” (*Id.*, [0078].) The light is directed to a plurality of SPAD detector arrays **2014**. (*Id.*) Each SPAD detector cell includes “the photon detector and its processing electronics comprising a Time to Digital converter TDC, local data processor of DSP type, data compressors, DSP.” (*Id.*, [0079].)

E. Spector (EX1005)

U.S. Patent No. 10,473,766 (“Spector”; EX1005)¹ discloses the LIDAR system shown below:

¹ Petitioner relies on U.S. Provisional Application No. 62,470,706 (“Spector Provisional”; EX1010) in asserting that Spector is prior art to the ’405 patent. (Pet. at 50-55.)

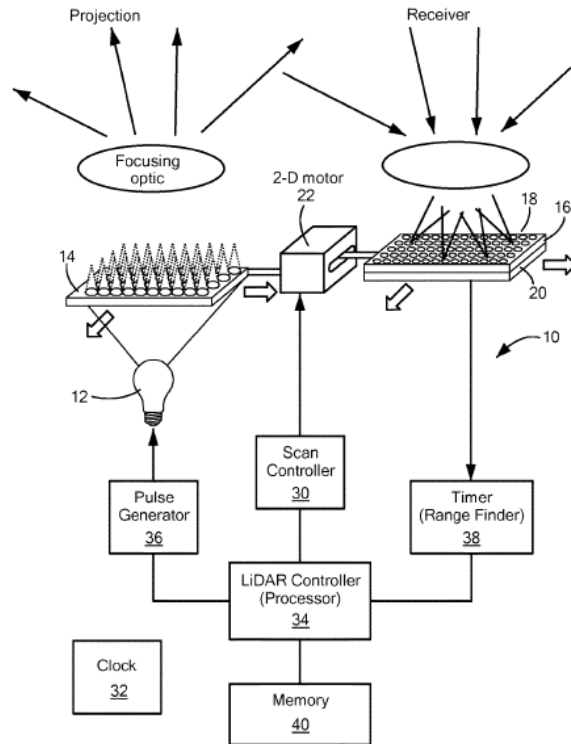


FIG. 1

(EX1005, Fig. 1.) A single light source **12** generates optical radiation that is subdivided by micro-optic array **14**, which projects “multiple light spots” into the surrounding environment. (*Id.*, 3:10-12.) When a fraction of the outgoing light is reflected back to the LIDAR system, it is focused by a lens, subdivided by aperture array **18**, and passed through to detector array **20**. (*Id.*, 3:43-45.)

To capture information about the complete scene, Spector discloses using movable stages driven by 2-D motor **22** to scan its microoptic and aperture arrays horizontally and vertically (*i.e.*, in the X-axis and Y-axis) along a plane as shown in Figure 1 (above) and Figure 9 (below):

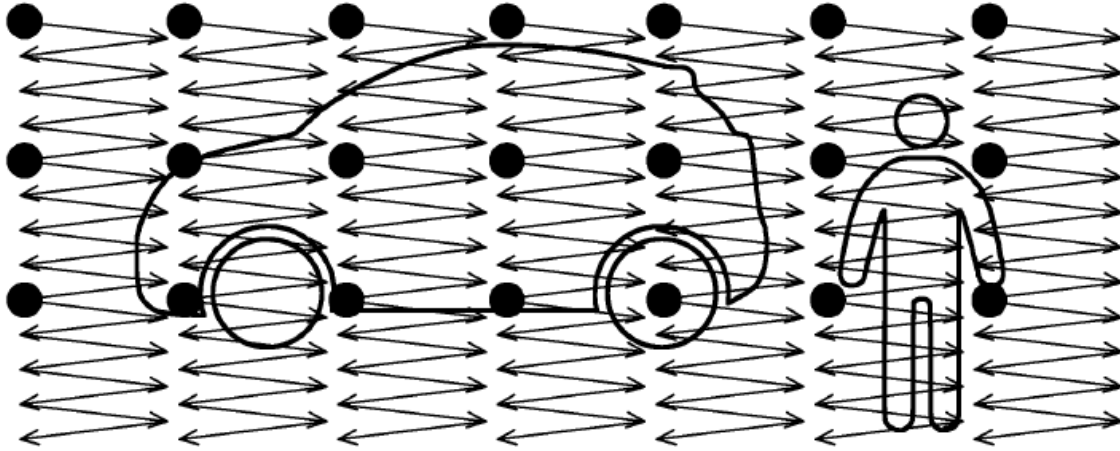
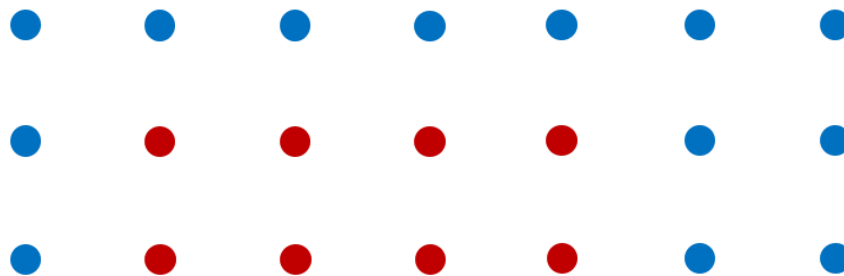


FIG. 9

(*Id.*, Fig. 9.) Spector discloses that the light spots and apertures should traverse the scene “no more than the distance between adjacent spots in the first dimensional direction and in the second dimensional direction[.]” (*Id.*, 1:62-67.) Spector requires both the transmitter micro-optic array **44** and the aperture array **18**/detector array **20** to scan at the same time (*i.e.*, synchronously). (*E.g.*, *id.*, 1:51-53, 3:62-65, Fig. 1.)

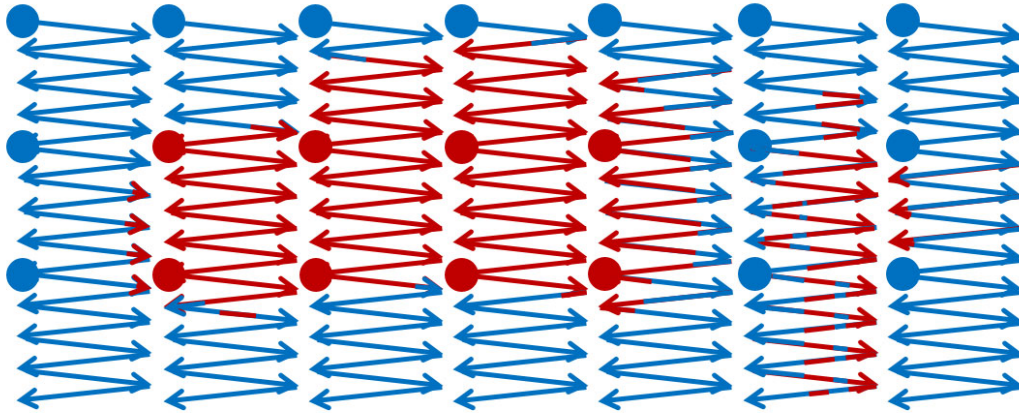
Based on Spector’s disclosures, a POSITA would have understood that horizontal and vertical scanning are necessary to “fill in” or “complete” an internal representation of a scene given the incomplete view of the scene provided by Spector’s microoptic and aperture arrays. For example, a POSITA would have understood that without horizontal and vertical scanning, Spector’s internal representation of the scene shown in Figure 9 would look like the below, with red

dots indicating nearer objects and blue dots indicating objects that are further away:



(EX2010, ¶132.) As the above demonstrative diagram indicates, a POSITA would have understood that, without horizontal and vertical scanning, Spector’s system would not have detected the person standing in the scene at all, since the person is standing in the interstices between the detection regions. *Id.*, ¶¶127, 132. Further, a POSITA would have understood that without that scanning, Spector’s system would have detected only an extremely low resolution representation of the car in the scene, and would not have been able to “see” the full height or width of the car. *Id.*, ¶¶132-42.

Further, a POSITA would have understood that the following demonstrative shows the internal representation of Spector’s system regarding the scene shown in Figure 9 when horizontal and vertical scanning is implemented:



(EX2010, ¶133.) As the above diagram indicates, both the person and the full height and width of the car are detected when Spector’s system implements horizontal and vertical scanning. *Id.*

F. Villeneuve (EX1007)

Petitioner relies on U.S. Patent No. 10,520,602 (“Villeneuve”; EX1007) in its challenge to certain dependent claims for Petitioner’s Ground 2. Since Villeneuve merely adds to proposed combinations that, as shown below, cannot be sustained, discussion of the additional references is currently unnecessary.

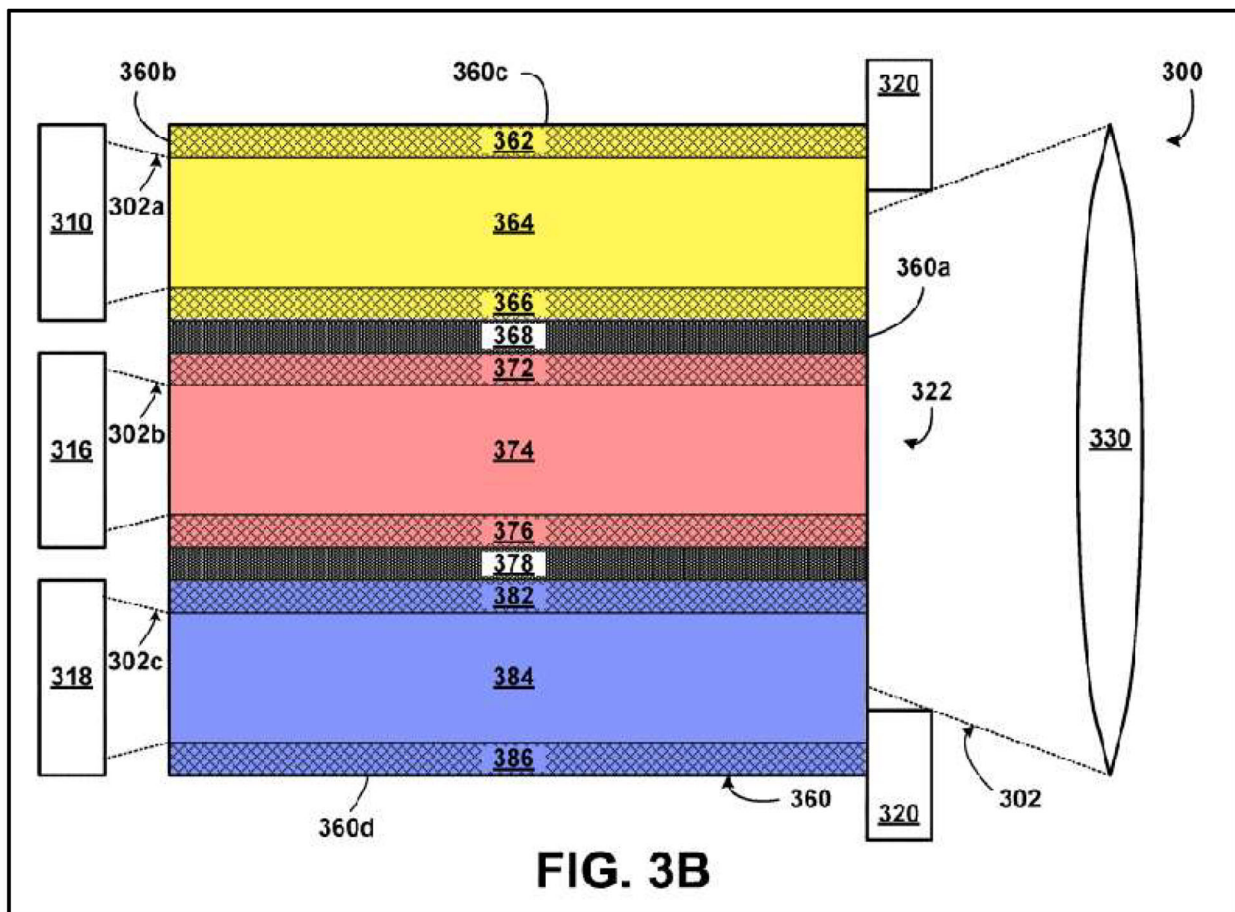
IV. THE BOARD SHOULD REJECT PETITIONER’S PROPOSED COMBINATIONS.

A. The Board Should Reject the Pacala-Droz Combination.

Petitioner characterizes Ground 1 as relying on Pacala for “the basic structure of a rotating LiDAR device” and “basic optoelectronic components,” and as relying on Droz for a number of features including the claimed alleged apertures, SPAD arrays, and optical filters. (Pet. at 17-18.) Ground 2 relies on the Pacala-Droz combination and adds Villeneuve for dependent claims 24-25 and 32-33.

1. The Pacala-Droz Combination Fails to Disclose the Claimed Aperture Layer Comprising a Plurality of Apertures Separated by a Stop Region.

Both of the challenged independent claims recite “**an aperture layer comprising a plurality of apertures separated by a stop region.**” Petitioner concedes that Pacala does not disclose the claimed aperture layer and thus relies on Droz. (Pet. at 26-27.) Petitioner focuses on Figure 3B of Droz as allegedly disclosing this claim limitation:



(EX1006, Fig. 3B (annotation in Pet. at 27).) Petitioner points to the waveguide array **360** in Figure 3B above as allegedly disclosing the claimed aperture layer.

(Pet. at 27.)

As shown, each of Droz’s waveguides consists of three layers—core layers (364, 374, 384), cladding layers (362, 366, 372, 376, 382, 386), and absorbing layers (368, 378). (EX1006, 13:27-43.) Petitioner contends that each of the input ends of the waveguides (shown on side 360a of Figure 3B) receives a portion of light 302 and discloses an “aperture,” as claimed. With respect to the claimed “stop region,” Petitioner points to the “layer of light-absorbing material” shown in absorbing layers 368 and 378 (in black above). (Pet. at 28.) Petitioner contends that “[t]he light-absorbing material comprises a stop region separating the apertures.” (Pet. at 28 (citing EX1003, ¶151).) The Petition provides no further explanation as to how absorbing layers 368 and 378 in Droz disclose the claimed stop regions.

Petitioner did not offer any proposed claim construction for “stop region.” When asked at his deposition, Petitioner’s expert testified that he understood the term “stop region” to simply refer to an element that “stops light from propagating in that area.” (EX2011, 53:7-10.) But this is an incorrect definition for “stop region,” and Droz fails to disclose a “stop region” under a proper construction.

(a) **The Term “Stop Region” Requires an Optically Non-Transparent Region That Defines a Field of View for a Photosensor**

The Federal Circuit has long made clear that the patent specification “is always highly relevant to the claim construction analysis. Usually, it is dispositive;

it is the single best guide to the meaning of a disputed term.” *Phillips v. AWH Corp.*, 415 F.3d 1303, 1315 (Fed. Cir. 2005) (en banc) (quoting *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996)). The term “stop region” should be construed as an optically non-transparent region that defines a field of view for a photosensor.

Patent Owner’s proposed construction flows directly from the ’405 patent specification. The specification describes “aperture layer **1740**” as including “an optically transparent aperture **1744** and optically non-transparent stop region **1746** configured to define a narrow field of view when placed at the focal plane of an imaging optic[.]” (EX1001, 37:17-23 (emphasis added).) This is shown in Figure 17, reproduced below, depicting stop region **1746**:

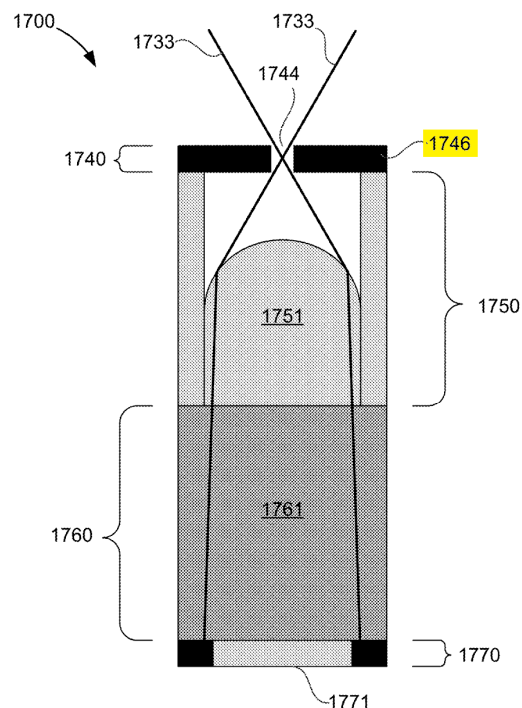


FIG. 17

(*Id.*, Fig. 17.) Stop region **1746** shown in Figure 17 above is not simply a non-transparent element that stops light propagating in an area—it defines the field of view for photosensor **1771**. In the example above, marginal ray lines **1733** represent the outermost angles of light that can pass through the field of view defined by stop region **1746**. (*Id.*, 37:23-25.) Light rays that reach aperture **1744** from a more extreme angle, for example, cannot enter the aperture and are blocked by stop region **1746** and thus will not reach photosensor **1771**. (EX2010, ¶102.)

The fact that a “**stop region**” is not simply any non-transparent element that stops light propagating in an area, as Petitioner’s expert contends, is further confirmed by examples in the specification of other non-transparent and light-blocking elements that do *not* define a field of view—and which the specification *never* describes as stop regions.

For example, using Figure 17 again as a reference, optical lens layer **1750** may optionally include “non-transparent regions and tube structures to reduce cross talk.” (EX1001, 37:46-49.) These are shown in blue in Figure 17 below:

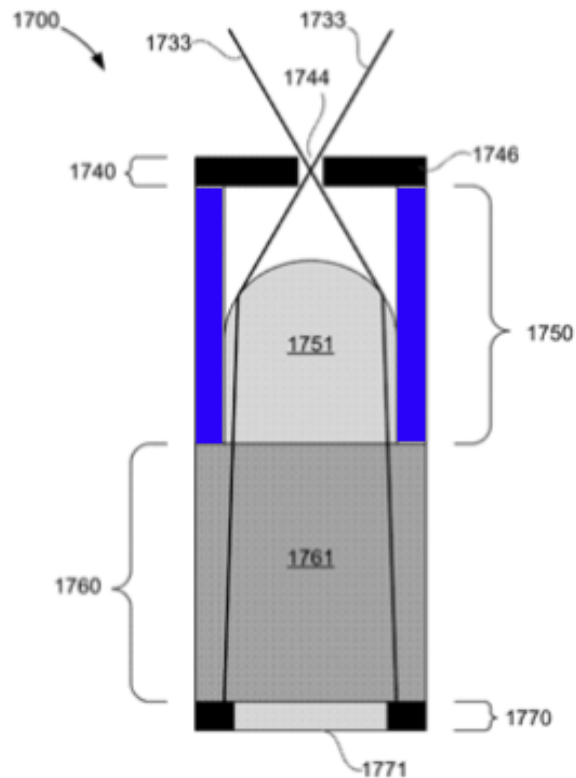


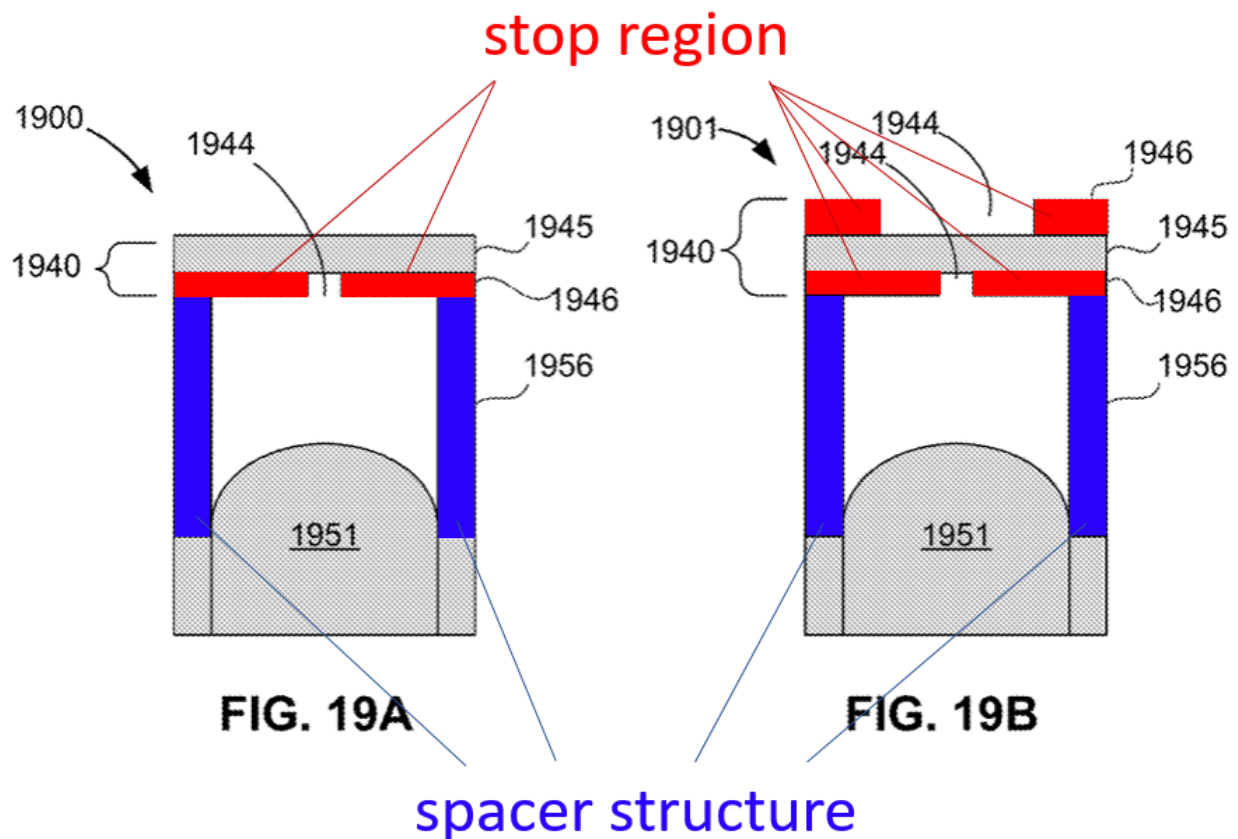
FIG. 17

(EX1001, Fig. 17 (blue emphasis added); EX2010, ¶103.) The '405 patent never suggests that the non-transparent regions or tube structures in **optical lens layer 1750** qualify as stop regions. Rather, they are simply non-transparent structures that stop light propagating sideways either in or out of optical lens layer **1750**.

And unlike stop region **1746** in Figure 17, the non-transparent regions in **optical lens layer 1750** do not define a field of view for photosensor **1771**. (EX1001, 37:46-49; EX2010, ¶103.) They merely reduce cross-talk with neighboring apertures. (*Id.*) As Patent Owner will demonstrate below, in fact, non-transparent structures in **optical lens layer 1750** of Figure 17 are remarkably similar

to absorbing layers **368** and **378** in Droz, which Petitioner relies on for the claimed stop regions.

Patent Owner's construction is consistent with other embodiments in the '405 patent specification. As another example, Figures 19A and 19B identify “**stop region**” as elements **1946**, an optically non-transparent material that defines the field of view for collimating lens **1951**:



(EX1001, Figs. 19A-B (colored annotations added); EX2010, ¶104.) Figures 19A and 19B show **stop region** 1946, as well as **spacer structure** 1956. As shown, **stop region** 1946, just like stop region 1746 in Figure 17 above, defines a field of view for collimating lens 1951 by restricting the beam of rays that can enter the aperture

and reach collimating lens **1951**. And just like Figure 17, Figures 19A and 19B describe **spacer structure 1956** as “[o]ptically non-transparent spacer structure **1956**” which “prevents any light from traveling outside the receiver channel[.]” (EX1001, 39:29-46, 39:47-59.) The ’405 patent never suggests that **spacer structure 1956** – which does not define the field of view for collimating lens **1951** – is a stop region. This provides yet another example of non-transparent, light-blocking elements that do **not** define the field of view, and which the ’405 patent explicitly does **not** describe as stop regions.

Patent Owner’s construction of “**stop region**,” and the use of the term in the ’405 patent specification, is entirely consistent with how persons of ordinary skill in the field understood this term. The Federal Circuit has explained that extrinsic sources such as expert testimony, dictionaries and learned treatises “may be helpful to explain scientific principles, the meaning of technical terms, and terms of art that appear in the patent and prosecution history.” *Markman v. Westview Instruments, Inc.*, 52 F.3d 967, 980 (Fed. Cir. 1995) (en banc), *aff’d* 517 U.S. 370 (1996). Multiple independent sources further confirm that the term “stop” when used in the context of an aperture—and consistent with the specification—is a term of art used to describe an element that restricts the path of light to define a field of view. (EX2010, ¶¶107-108.)

As explained in Warren J. Smith, *Practical Optical System Layout and Use of*

Stock Lenses (1997):

2.2 Stops and Pupils

We begin with a discussion of an often neglected but vital aspect of optical systems, the concept of the *aperture stop*. In every optical system there is some feature, usually a diameter, which limits the size or diameter of the beam of rays which can pass through the system. If the system consists of just a single simple lens, the aperture stop is just the clear aperture of the lens. In a typical camera lens the iris diaphragm is the aperture stop. In a telescope the clear aperture of the objective lens (or that of the primary mirror) is ordinarily the aperture stop. Often the aperture stop is referred to simply as “the stop.”

(EX2013, p. 49; EX2010, ¶108.) Anyone who has ever used a camera or microscope would likely recognize the “iris diaphragm” referenced above, which is a device having a series of thin metal blades that can be adjusted to vary the size of a camera aperture and thus the beam of rays that can reach the camera lens. (*Id.*)



A similar description of aperture stops is provided in Frank L. Pedrotti et al., *Introduction to Optics* (3d ed. 2006):

Image Brightness: Aperture Stops and Pupils

Aperture Stop (AS) The *aperture stop* of an optical system is the actual physical component that limits the size of the *maximum cone* of rays—from an axial object point to a conjugate image point—that can be processed by the entire system. Thus it controls the brightness of the image. The diaphragm of a camera and the iris of the human eye are examples of aperture stops. Another example is found in the telescope, in which the first, or objective, lens determines how much light is accepted by the telescope to form a final image on the retina of the eye.

(EX2007, p. 21; EX2010, ¶107.) The description above is entirely consistent with

the “stop region” described in the ’405 patent, as it limits the field of view (and thus the maximum “cone of rays”) for the aperture. The Board should thus construe “stop region” as an optically non-transparent region configured to define a field of view for a photosensor. (EX2010, ¶¶99-100.)

(b) Droz Fails to Disclose the Claimed “Stop Region” When Properly Construed.

As noted previously, Petitioner has identified absorbing layers **368** and **378** in Droz as the claimed “stop regions.” (Pet. at 27.) This is Petitioner’s only effort to find a structure corresponding to the claimed stop regions. Droz does not, however, disclose a stop region and accordingly, Petitioner’s Grounds 1 and 2 fail.

Referring to Droz Figure 3B:

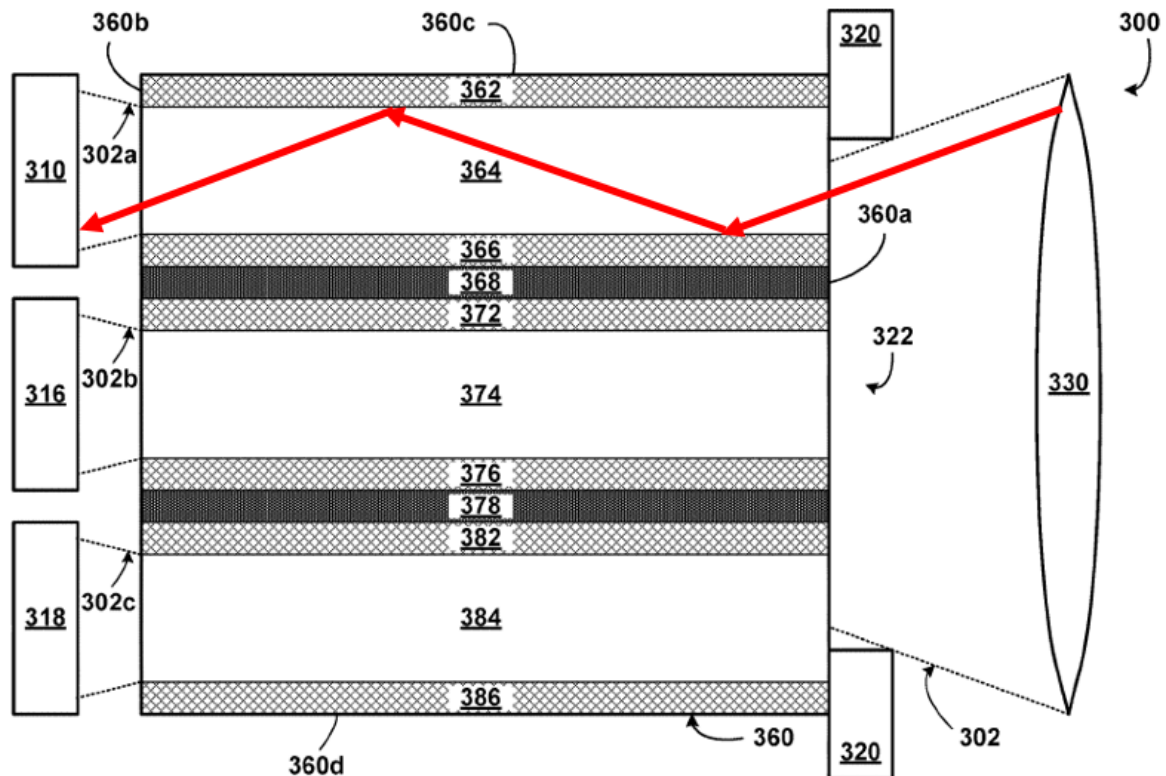


FIG. 3B

(EX1006, Fig. 3B (colored annotations added); EX2010, ¶109.) Absorbing layers **368** and **378** do not qualify as “**stop regions**” under the proper construction described above because they do not define the field of view of the detector. (EX2010, ¶109.)

The waveguides in Droz instead have reflective cladding layers (**362**, **366**, **372**, **376**, **382**, **386**) that reflect light in order to guide it along the path of the waveguide. (EX1006, 14:23-33; EX1003, ¶150 (discussing “cladding layers . . . that reflect light that reaches the edge of the core layer in order to guide it along the path defined by the waveguide”).) An exemplary path of light is shown in the **red** arrow annotation above. (EX2010, ¶109.) Accordingly, when a light ray enters a Droz

waveguide from an angle, it is reflected along the path of the waveguide by the reflective cladding layers – it is **not** stopped along that path by absorbing layers **368** or **378**. (*Id.*) Rather, the sole function of absorbing layers **368** and **378** is preventing leakage or cross-talk *between* neighboring waveguides, as shown in the annotated Figure 3B below.

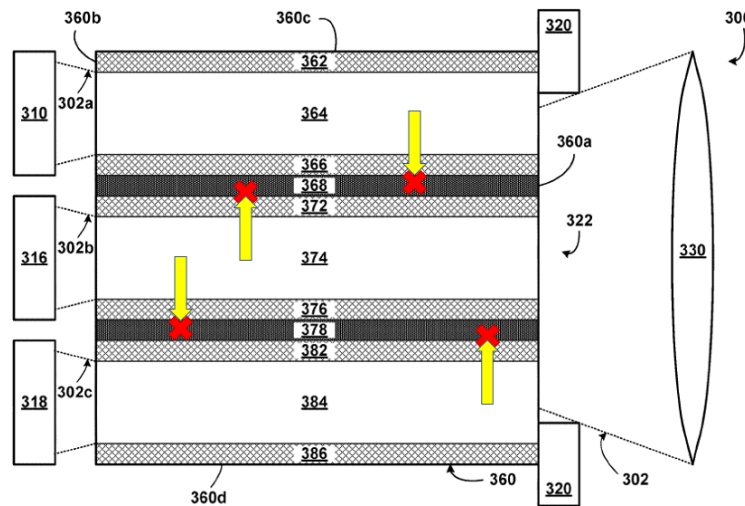


FIG. 3B

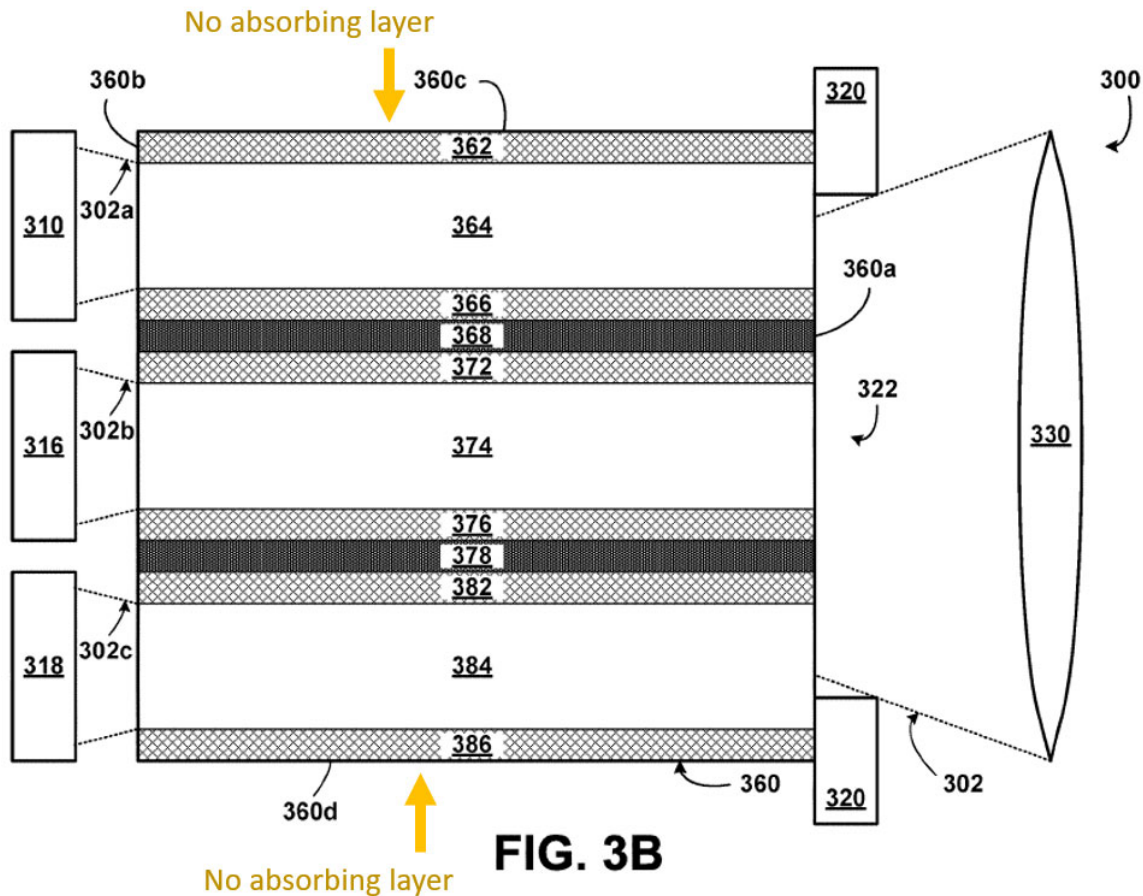
(EX2010, ¶97 (citing EX1006, Fig. 3B (annotations added)).) As shown, absorbing layers **368** and **378** are designed to prevent light in one waveguide from leaking into neighboring waveguides. (EX1006, 14:51-60 (“As a result, guided light in the first waveguide may potentially leak through cladding **366** as an evanescent field evanescent toward the second waveguide. To mitigate this leakage, as shown, absorbing layer **368** includes an absorber (e.g., carbon black) that has a suitable thickness to absorb the evanescent field evanescent from the first waveguide and/or the second waveguide. Similarly, absorbing layer **378** may be configured to absorb evanescent

light between the second and third waveguides.") (underlining added.) In fact, absorbing layers **368** and **378** in Droz are remarkably similar to the non-transparent structures depicted in the '405 patent discussed above that are *not* stop regions, *e.g.*, "non-transparent regions and tube structures to reduce cross talk" in Figure 17, or the "[o]ptically non-transparent spacer structure **1956**" in Figures 19A-B that "prevents any light from traveling outside the receiver channel." (EX1001, 37:46-49, 39:32-36, 39:52-57; EX2010, ¶¶104-105.)

Nothing in Droz suggests that the absorbing layers (**368**, **378**) have any role in defining the field of view for the light detectors (**310**, **316**, **318**). Nor could they, as the waveguides have reflective cladding layers (**362**, **366**, **372**, **376**, **382**, **386**) running along the entire length of the waveguide, that reflect and propagate light along the waveguide path. Nothing in Droz suggests that absorbing layers (**368**, **378**) in any way restrict the beam of light that can enter the waveguides. Droz in fact uses an entirely different technique to define the field of view for the light detectors—relying on the size of the input ends of the waveguides. (EX1006, 16:59-67 ("By way of example, an input end of the first waveguide extending between cladding layers **362** and **366** can have a different size than an input end of the second waveguide extending between cladding layers **372** and **376**. In this example, light portion **302a** detected at light detector array **310** may correspond to a greater or lower range of angles scanned within a field-of-view (FOV) of system **300**,

compared to a range of angles scanned within the FOV and detected as light portion **302b** at light detector array **316**.”) (underlining added.) This technique does not involve the use of stop regions. (EX2010, ¶¶97-101, 109.)

If Droz’s absorbing layers **368** and **378** were for defining a field of view for the light detectors (and not just for preventing leakage between waveguides), then a POSITA would expect Droz to disclose that each waveguide is associated with its own *pair* of absorbing layers. (EX2010, ¶101.) But Droz discloses that only *some* waveguides—*i.e.*, those that have neighboring waveguides on both sides—have two absorbing layers. Other waveguides—*i.e.*, those that have only a *single* neighboring waveguide—have only a *single* absorbing layer:



(EX2010, ¶101 (providing annotated version of Droz’s Figure 3B).) In other words, a Droz waveguide only has as many absorbing layers as it does neighbors. (EX1006, 16:35-36 (discussing “absorbers **368** and **378** appropriately interposed between the various waveguides”).) This confirms that the absorbing layers in Droz function to limit cross-talk from neighboring waveguides. They do *not* function to define the field of view for a single waveguide. Accordingly, the absorbing layers **368** and **378** are clearly *only* for preventing leakage between waveguides—not for defining the field of view of the photosensors.

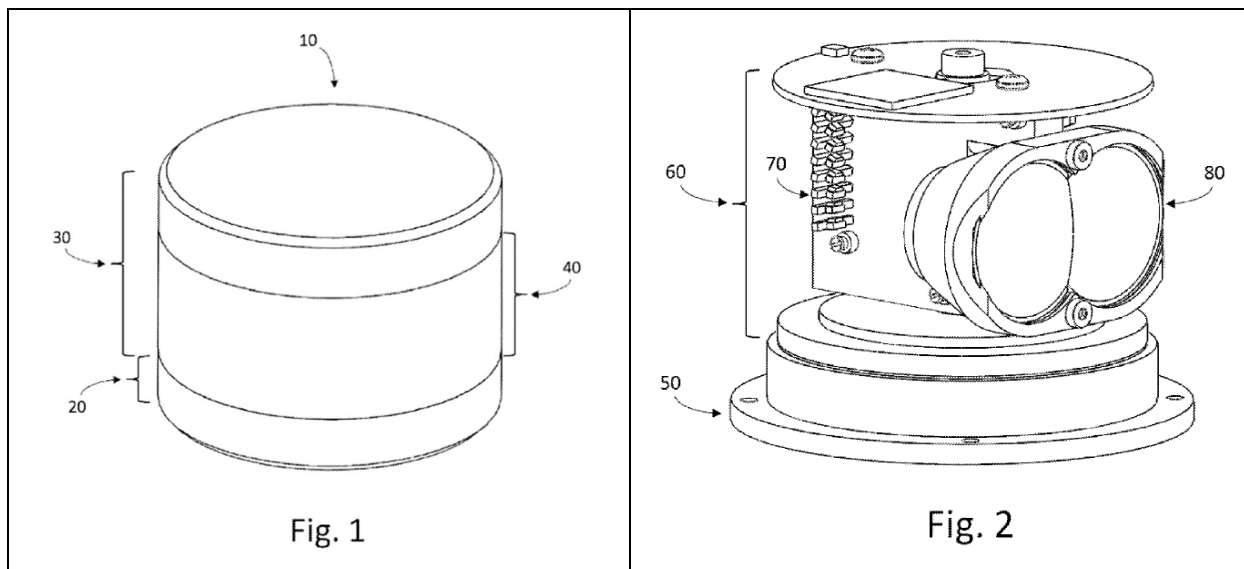
Because Droz fails to disclose “an aperture layer comprising a plurality of

apertures separated by a stop region,” and Ground 1 of the Petition relies solely on Droz for this limitation, the Pacala-Droz combination fails.

2. An Ordinarily Skilled Artisan Would Not Have Been Motivated to Combine Pacala and Droz.

“When an obviousness determination relies on the combination of two or more references, there must be some suggestion or motivation to combine the references.” *Intelligent Bio-Systems, Inc. v. Illumina Cambridge Ltd.*, 821 F.3d 1359, 1368 (Fed. Cir. 2016) (quoting *WMS Gaming, Inc. v. Int’l Game Tech.*, 184 F.3d 1339, 1355 (Fed. Cir. 1999).) Petitioner here presents a number of generic arguments why a skilled artisan would allegedly have been motivated to apply elements in Droz to Pacala’s broader system including SPAD arrays, optical filters, and waveguide arrays. (Pet. at 18-20.) Petitioner and its expert have ignored the substantial differences between the Pacala and Droz systems and the potentially insurmountable challenge presented by attempting to incorporate the waveguides of Droz into the Pacala system. These problems, as explained below, refute any motivation to combine. *See Sound View Innovations, LLC v. Hulu, LLC*, 818 F. App’x 1009, 1013 n.3 (Fed. Cir. 2020) (“The impracticality of the prior art combination may be a factor in determining whether there would have been a motivation to combine.”).

Pacala discloses a compact LiDAR system whose components are tightly packed into spinning turret **60**, as depicted in Figures 1 and 2:



(EX1004, Figs. 1-2.) Figure 2 shows “a static base **50** that contains a motor and distributed electronics, and a spinning turret **60** that contains optoelectronic components **70** (including optical transmitters and receivers), collimation and focusing lenses **80** and distributed electronics.” (EX1004, ¶[0013].) Pacala also repeatedly emphasizes the cost-effectiveness of its compact design. (EX1004, *e.g.*, ¶¶[0003], [0010], [0014].)

Under the proposed Pacala-Droz combination, the waveguides of Droz would have been incorporated into Pacala’s system, and as Petitioner’s expert acknowledged, the waveguides in the Pacala-Droz combination would have spun. (EX2011, 54:3-5 (“Q. So the waveguides in the Pacala-Droz combination would spin or rotate; is that correct? A. Yes.”).) But this combination would have presented so many substantial engineering challenges that a person of ordinary skill in the art would not have been motivated to make it.

One of the key problems that Petitioner and its expert fail to acknowledge – let alone address – is that Droz does not disclose the type of 360-degree rotating LiDAR system described in Pacala. Petitioner and its expert do not explain how the waveguides of Droz would have been incorporated into the Pacala system; as demonstrated below, Petitioner’s expert acknowledged at his deposition that he had no idea how this could be done, and that the proposed combination would have required excessive experimentation by an entire team of people.

Referring back to Figure 3B of Droz, it discloses waveguides comprised of three different types of layers:

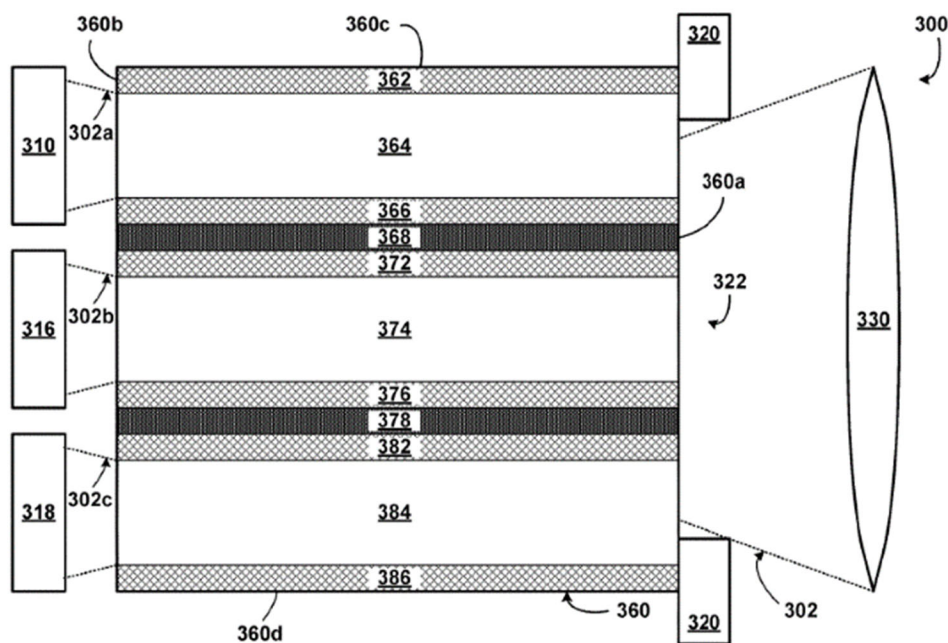


FIG. 3B

(EX1006, Fig. 3B.) First are the waveguides’ “core layers” (elements **364**, **374**, and **384** in Figure 3B), which consist of a “relatively high index of refraction material, such as a glass or high-index polymer substrate for instance[.]” (EX1006, 13:35-

38.) Second, the waveguides include “cladding layers” (elements **362, 366, 372, 376, 382, and 386** in Figure 3B), which consist of “a relatively low index of refraction material, such as polymer coated or fluorine-doped glass substrates[.]” (*Id.*, 13:31-34.) Droz indicates that each waveguide has multiple cladding layers. (*See id.*, Fig. 3B.) Third, the waveguides include “absorbing layers,” comprised of a material that absorbs light like carbon black or black chrome. (*See id.*, 13:39-43.) Accordingly, the waveguides of Droz consist of “stacked” plates and layers, each of which consists of solid material. (*Id.*, 4:29-39; EX2010, ¶¶112-13.)

Under the proposed Pacala-Droz combination, each pixel of photodetectors in would have a waveguide. (EX1003, ¶128.) The Pacala reference discloses the use of eight photodetector channels. (EX1004, Fig. 2.) Accordingly, the Pacala-Droz combination would have required at least eight core layers of stacked plates of glass or polymer, at least seven absorbing layers of carbon black or black chrome (between the core layers), and at least sixteen cladding layers made of polymer-coated or fluorine-doped glass (sandwiching the core layers). (EX2010, ¶¶112-13.) Further, Droz discloses implementations where cladding layers completely surround the core layers of the waveguides, leading to even more solid material being necessary to construct the waveguides. (EX1006, 14:61-15:12; EX2010, ¶¶112-13.)

Petitioner and its expert provide only generalities about the Pacala-Droz combination, and provide no any analysis or reasoned explanation as to how the proposed

combination could have been built. Indeed, in his deposition, when asked how large the Pacala-Droz system combination would be, Petitioner's expert responded: "I really can't answer that. I don't know dimensions of objects and the system requirements and things like that." (EX2011, 54:6-13.)

Petitioner's expert further testified that he could not say how much the combined Pacala-Droz system would weigh. (EX2011, 54:6-13.) He made clear that he "couldn't venture a guess" as to the mass distribution of the combined Pacala-Droz system. (*Id.*, 54:20-55:4; see also *id.*, 56:21-57:2 (stating he "[doesn't] have any of the data to do" the analysis necessary to calculate the mass distribution for the Pacala-Droz combination).) But without analysis accounting for the impact of Droz's waveguides on the weight of the combined Pacala-Droz system, Petitioner's expert has no basis to opine that a skilled artisan would have been motivated to make the combination.

As noted, adding the stack of solid materials in Droz's waveguides to the spinning Pacala system would have changed the gyroscopic forces acting on the spinning system. (EX2010, ¶118.) Petitioner's expert testified that in a spinning system, something can "go flying off" if the design is inadequate. (EX2011, 61:2-11.) But he also provided no analysis to explain how the design of the proposed Pacala-Droz system would accommodate the gyroscopic forces caused by the addition of the Droz waveguides to the spinning Pacala system. (*Id.* (testifying that effective

incorporation of the Droz waveguides into the Pacala system “depends on how good your design is”).) Further, Petitioner’s expert testified that he did not “know all the materials in the system” for the Pacala-Droz combination—making the issues discouraging the combination of these references particularly acute. (*Id.*, 54:20-55:10.)

To make matters worse, Petitioner’s expert testified that he did not know if it would have taken a POSITA more or less than a man-year (which he defined as 2,000 hours) of work by a skilled artisan to combine the Pacala and Droz systems. (EX2011, 60:2-19.) Further, in his view, a POSITA would not even have been a single individual but a team of engineers, including an optical engineer, an electrical engineer, and a mechanical engineer. (*Id.*, 57:3-58:21 (“[Y]ou have to have a team to put all these pieces together.”).) He further testified about the many steps required for a POSITA team to combine the Pacala and Droz systems:

[U]sually the way these things are done is that there’s a team of people, and there’s the system guy who sets all the requirements, and he sort of runs the whole program. And then there’s the optics guy saying, “Well, you’ve got to design optics for such-and-such a thing.” And the electrical engineering guy says, “Okay, this is going to be my focal plane. This is going to be my laser. These are my electronic requirements.” And then there’s the mechanical guy, that says, “Okay, you guys, give me all that stuff and then I’ll wrap my metal around it and design all the housing and stuff like that.”

(EX2011, 57:11-58:1.)

I might caveat that also saying that when you start a system like this, you start looking at components and component availability and things. And I've been on systems where you required a detector array which wasn't off the shelf. And so you had to visit vendors and say, "Hey, I want a 1080-by-1024 array." And so it's not really quantifiable until you have a lot of information.

(*Id.*, 60:12-19.)

Petitioner's expert thus confirmed that combining the Pacala and Droz systems would have been a complex and work-intensive operation, requiring a multidisciplinary team and potentially thousands of hours of engineering time.

"To render a claim obvious, the prior art, taken as a whole, must enable a skilled artisan to make and use the claimed invention." *Raytheon Techs. Corp. v. Gen. Elec. Co.*, 993 F.3d 1374, 1380 (Fed. Cir. 2021). Based on the issues with combining Pacala's spinning LIDAR system with Droz's stack of solid waveguide layers—including volume, weight distribution, and rotational forces—a POSITA would not have been motivated to combine these systems. (EX2010, ¶121.) Petitioner has thus failed to show a motivation to combine the Pacala and Droz systems, and also failed to show a reasonable expectation of success or an enabled combination.

B. The Board Should Reject the Hall-Borowski-Spector Combination.

Petitioner relies on Hall as the primary reference in Grounds 3 and 4, asserting that Hall discloses “the basic structure of a rotating LiDAR device” and certain optoelectronic components. (Pet. at 55.) Because Hall does not disclose SPADs, Petitioner asserts that it would have been obvious to combine Hall with Borowski to import SPADs into Hall’s system. (*Id.*) And since neither Hall nor Borowski discloses the claimed apertures, Petitioner adds Spector to the combination in an effort to import micro-optics and apertures. (*Id.*) The Board should reject Grounds 3 and 4 because Petitioner failed to provide an adequate motivation to combine.

1. An Ordinarily Skilled Artisan Would Not Have Been Motivated to Combine Hall with Spector.

Spector discloses a system that detects distances to objects in a single scene—*i.e.*, the view of the external environment to the system from in a single direction. (EX1005, 1:19-21 (defining a “scene” as “a contiguous portion of a physical space accessible to being viewed”); EX1010 at 13 (“To fill the scene, the illumination and detector aperture only have to be scanned the distance between illumination spots.”); *id.* at 18 (showing the scanning of a single direction under the title “Scanning the Scene”); EX2010, ¶125.)

The system in Spector relies on a light source behind an array of microlenses, causing a two-dimensional array of light spots to be projected onto the scene. (EX1005, Fig. 9, 3:1-3; EX1010 at 12, 17-18.) On the receiver side of Spector’s

system, an aperture array is used to direct light from the illuminated points of the scene onto an array of detectors. (EX1005, Fig. 1, 3:28-31, 3:38-42; EX1010 at 12, 17, 19.) The detected points of the scene are shown in Figure 9 of Spector as the two-dimensional grid of dots:

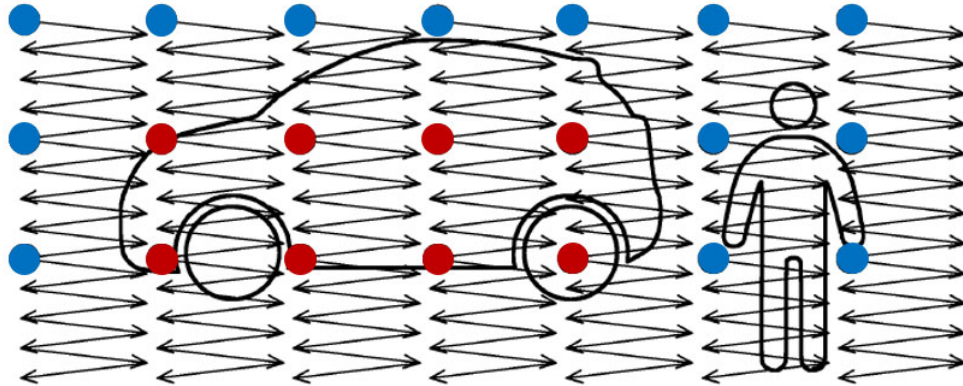
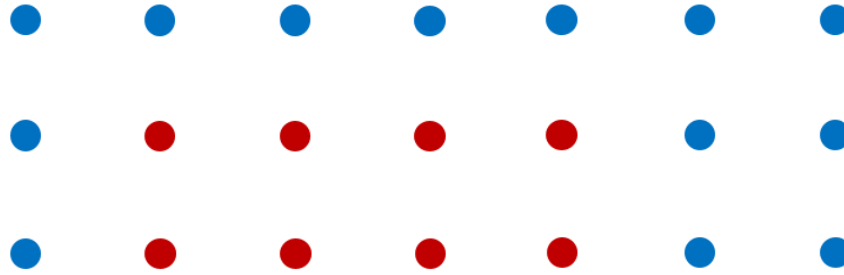


FIG. 9

(EX1005, Fig. 9 (colored annotations added); EX1010 at 18; EX2010, ¶132.)

One of the challenges of using Spector's system is that the arrayed micro-lenses and aperture array only detect *discrete points* of the scene, shown in dots above, resulting in a partial view of the scene. (EX2010, ¶132.) For example, focusing the detection points shown in red from Figure 9 above, reveals how little resolution is captured by the aperture array:



(*Id.*) To the extent light relating to the car from Figure 9 is captured by light entering these detection points, it is nothing more than a nondescript rectangle with no detail.

(*Id.*) Spector overcomes this limitation by causing the microoptics and aperture arrays to *move* in order to fill in the gaps between the discrete detection points. (*Id.*, ¶¶126-27, 133-34.) This is shown in the annotated Figure 9 above, which shows the zig-zag lines reflecting the horizontal and vertical scanning movement of the aperture array to capture the scene including the car and the person in the field of view. More specifically, Spector discloses scanning via back-and-forth motion less than the distance between the apertures to capture the scene. (EX1005, 4:55-65; EX1010 at 13.)

To illustrate the importance of this scanning motion, consider the following color-annotated figure based on Figure 9 from Hall:

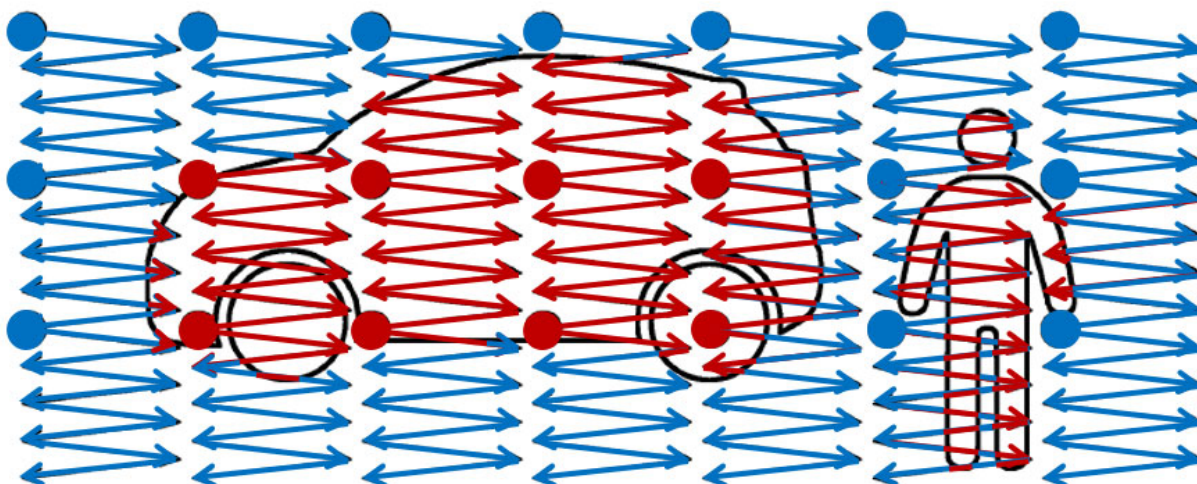
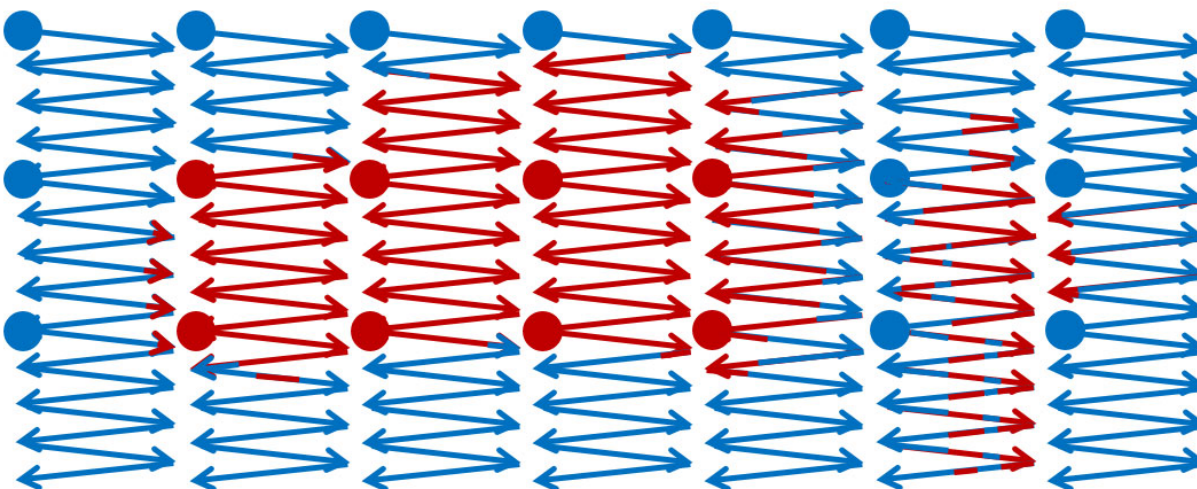


FIG. 9

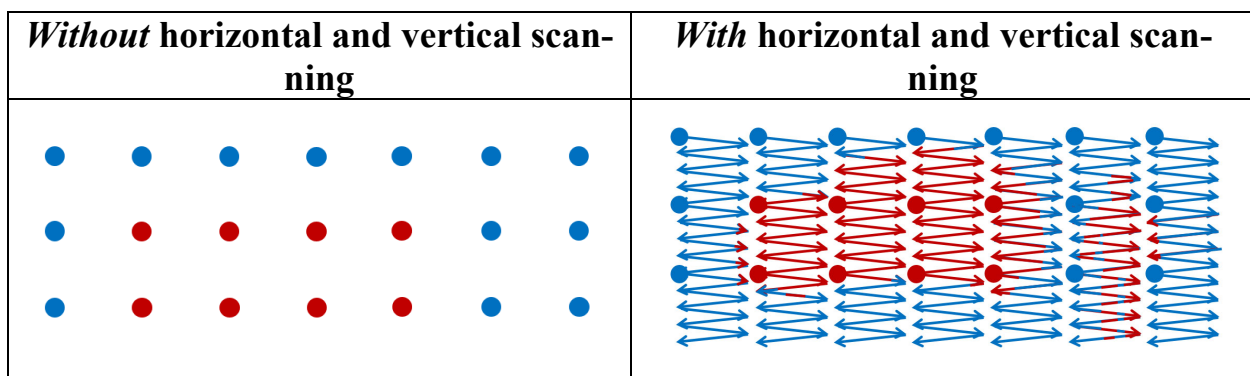
(EX1005, Fig. 9 (colored annotations added); EX1010 at 18; EX2010, ¶133.) Removing the underlying scene from the above demonstrative shows the level of detail generated by Spector’s system given the use of horizontal and vertical scanning:



(EX2010, ¶133.) The outline of the car and the person can be readily identified from the resulting detection data. (*Id.*; EX1005, 2:11-16 (“The two dimensional array of

light spots are scanned to complete a scan of the scene in such a manner that the spots traverse the scene in the first dimensional direction and in the second dimensional direction[.]” (emphasis added).)

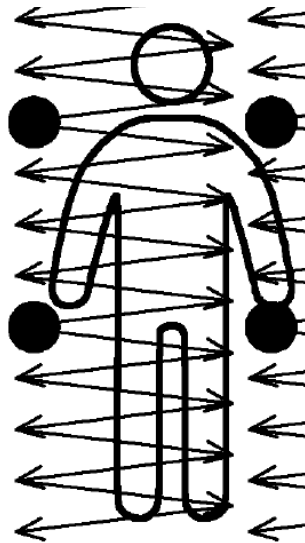
The horizontal and vertical scanning is thus an essential part of the Spector system; the figure below illustrates what would happen if one were to remove this feature from Spector:



(EX2010, ¶¶132-34.) The figure on the left shows how Spector would operate without the horizontal and vertical scanning – it would simply detect a disconnected series of discrete and spatially separated points with no accompanying detail. In this case, the car in the scene has been reduced to a non-descript rectangle. (*Id.*, ¶132.)

This presents a key problem to the proposed combination and refutes Petitioner’s arguments that a skilled artisan would have been motivated to combine Hall with Spector. The Board’s Institution Decision observed that, in the proposed Hall-Borowski-Spector combination, the combined system would **not** have incorporated Spector’s horizontal and vertical scanning (gimballing) of the aperture array to capture the full detail of the scene. (Institution Decision, at 24 (“Here, Petitioner

proposes using the apertures used in Spector's LIDAR device in Hall's device. Petitioner does not propose incorporating Spector's light source or its gimbal.") (underlining added); internal citation omitted) (citing Pet. at 65).) But the omission of that functionality would have resulted in exceedingly low resolution with most of the environment entirely undetected by the Hall-Spector system, as explained above. (EX2010, ¶¶126-27, 132-38.) Using the example in Figure 9 from Spector, in fact, this would have resulted in the human being going entirely undetected:



(EX1005, Fig. 9 (excerpt); EX1010 at 18; EX2010, ¶¶127, 132.) As shown in Figure 9 above, the discrete points shown by the black dots – without the horizontal and vertical movement as shown by the zig-zag lines – do not intersect with the human being in the figure. (EX2010, ¶¶127, 132.) This would thus result in the potentially disastrous outcome of not detecting the human being standing directly in the scene. (*Id.*)

The Federal Circuit has explained that “[i]f references taken in combination would produce a ‘seemingly inoperative device,’” then “such references teach away from the combination and thus cannot serve as predicates for a prima facie case of obviousness.” *McGinley v. Franklin Sports, Inc.*, 262 F.3d 1339, 1354 (Fed. Cir. 2001) (citing *In re Sponnoble*, 405 F.2d 578, 587 (C.C.P.A. 1969)). The Hall-Spector combination would have produced a device clearly inoperative for its intended purpose of providing a useful LiDAR sensor. (EX2010, ¶¶131, 137-39.) Hall specifically discusses the importance of point cloud density and “maintaining sufficiently high levels of imaging resolution and range.” (EX1008, 2:34-38, 2:46-48.) Hall describes exemplary applications involving mounting its system to a “vehicle operating on a roadway.” (*Id.*, 3:3-4.) But a person of ordinary skill in the art would have recognized that the sensor resulting from the Hall-Spector combination would have had woefully inadequate resolution and point cloud density—so bad that it would not have detected a human being standing in the scene, let alone identified a car or determined its length or height. (EX2010, ¶¶126-27, 132-38.) An ordinarily skilled artisan would not have been motivated to combine Hall with Spector in light of these gaping holes the combination would have created—both in the captured image itself and in the efficacy of the system as a whole. (*Id.*)

Petitioner and its expert assert that a person of ordinary skill in the art would have been motivated to combine Hall with the microoptic and aperture arrays of

Spector to avoid cross-talk. (Pet. at 57 (citing EX1003 ¶191).) Petitioner further argues that “[t]he array of isolated light spots generated by the arrayed micro-optic, in combination with the individual optical detection sites, in a one-to-one correspondence, reduce cross-talk and multipath signals.” (Pet. at 58.) But the purported benefit of this “array of isolated light spots” comes at the heavy cost of rendering the Hall device inoperative for its intended purpose. And Hall itself already discloses techniques for reducing or eliminating cross-talk. (EX1008, 9:16-17 (“In this manner, there is no cross-talk among any of the sixteen multi-pulse illumination systems.”), 9:21-25 (“In some of these embodiments, care is taken to ensure that there is sufficient spatial separation between the areas of the surrounding environment interroated [sic] by each beam to avoid cross-talk.”).) Petitioner and its expert do not explain why a skilled artisan would have found the Spector approach to reducing cross-talk preferable to the one already disclosed in Hall—particularly given the numerous problems of spatial separation that would have been created by adding the Spector aperture array (without its gimbaling feature). (EX2010, ¶¶126-27, 132-41.) To the contrary, any motivation to combine with Spector related to reducing cross-talk would have been heavily outweighed by the massive problems the combination would have introduced. (*Id.*, ¶¶138-42.)

Aside from the lack of a motivation to combine, Petitioner has also failed to show any reasonable expectation of success. Petitioner and its expert provide no

explanation as to how an ordinarily skilled artisan could have filled the gaps left by the proposed combination, and no such solution is suggested in either Hall or Spector. With respect to Hall, Petitioner has not asserted that the combination with Spector would have involved *any* change to the existing scanning mechanism of Hall. Hall does not disclose or suggest an aperture array at all; it instead relies on an entirely different solution of using a series of lenses (**116A**, **116B**, **116C**, **116D**) to direct collected light onto the detecting elements, as shown in Figure 5:

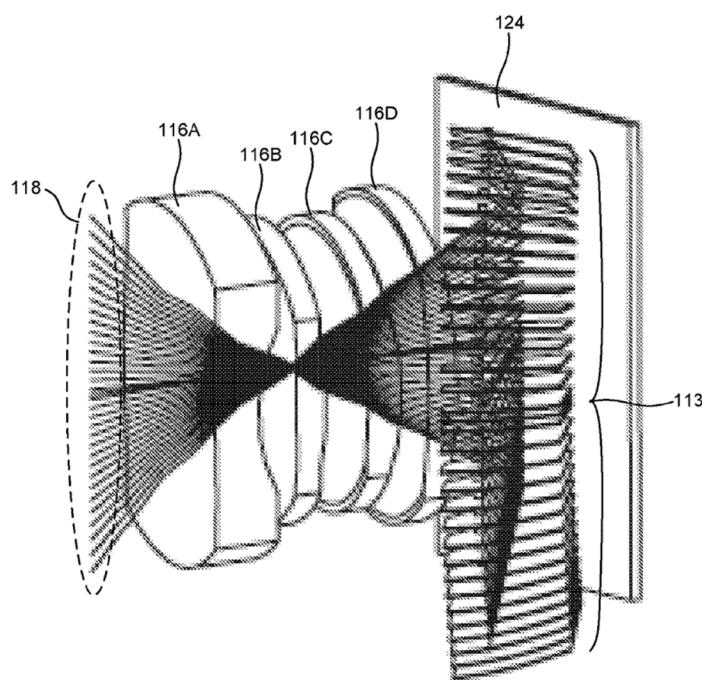


FIG. 5

(EX1008, Fig. 5.) In Figure 5 above, “[c]ollection optics **116** include four lens elements **116A-D** arranged to focus collected light **118** onto each of the array of detecting elements **113**.” (*Id.*, 7:8-10.) Nothing in this arrangement uses apertures, and in

fact, the word “aperture” appears nowhere in Hall. Hall is thus unhelpful to Petitioner in remedying the inoperativeness of the proposed Hall-Spector combination.

Moreover, to the extent Hall has anything to say about the horizontal and vertical scanning technique in Spector, it actively discourages its use. For example, Hall states that in some such systems, “a 2-D instrument is actuated up and down and/or back and forth, often on a gimbal. This is commonly known within the art as ‘winking’ or ‘nodding’ the sensor.” (EX1008, 1:45-48.) Hall describes disadvantages of this approach—the one adopted in Spector—by explaining that “[t]he number of pixels such devices can generate per unit time is inherently limited due limitations [sic] on the pulse repetition rate of a single laser.” (*Id.*, 1:57-60.) “Any alteration of the beam path [by]... actuation of the device that achieves a larger coverage area,” Hall explains, “comes at a cost of decreased point cloud density.” (*Id.*, 1:57-63.)

Spector similarly provides no solution to the problem that Petitioner’s combination creates. The Spector provisional application (the only portion of Spector on which Petitioner can rely as prior art predating the ’405 patent) is an exceedingly sparse document consisting of a handful of paragraphs and a few PowerPoint slides. (EX1010.) Spector does not suggest, let alone disclose, any embodiment that does not involve moving the aperture array platform horizontally and vertically to capture the full detail of the scene. Because Petitioner’s proposed Hall-Spector combination

omits that feature, the resulting combination is inoperative for its intended purpose and lacking any reasonable expectation of success. (EX2010, ¶¶137-38.)

Finally, it is possible that Petitioner and its expert may attempt to change their theory in reply to argue that the Hall-Spector combination *would* have included the scanning movement of the aperture array described in Spector. This change of theory would be improper. *See Intelligent Bio-Systems*, 821 F.3d at 1370 (“[T]he Board did not err in refusing the reply brief as improper... because [Petitioner] relied on an entirely new rationale to explain why one of skill in the art would have been motivated to combine[.]”).) Nevertheless, even if Petitioner were permitted to improperly switch horses and pursue such a theory, the Hall-Spector combination would *still* fail. This is because Hall discloses a rotating LiDAR system that can rotate at high speed. (EX1008, *e.g.*, 1:40-41 (“thousands of revolutions per minute”), 6:22 (“more than 200 revolutions per minute”).) If Petitioner were to argue in reply that Spector’s moving platform system were incorporated into Hall’s rotating LiDAR system, the resulting system would be rotating *at the same time* Spector’s aperture array platform was moving to complete the scan of a scene. Spector’s moving platform system would thus never complete the scan of a scene because, as it scanned horizontally and vertically, the scene would be changing due to the simultaneous rotation of Hall’s system. (EX2010, ¶¶128-31.) Accordingly, incorporating Spector’s moving platform system into Hall’s rotating LIDAR system would have

defeated the purpose of Spector's moving platform system. (*Id.*)

2. An Ordinarily Skilled Artisan Would Not Have Been Motivated to Combine Borowski with Spector

A POSITA would not have had a reasonable expectation of success of using Borowski's SPAD arrays with Spector's apertures. Petitioner asserts that it would have been obvious to incorporate Spector's apertures into a system using Borowski's SPAD arrays. (Pet. at 55.) However, Spector discloses that apertures are *only* beneficial for detectors with a large fill factor (*i.e.*, the ratio of sensor size to the spaces between sensors). (EX1005, 3:54-56; EX1010, ¶144.) For detectors with a small fill factor—*e.g.*, “less than 10%”—Spector discloses that apertures are *not used*. (EX1005, 3:49-54; EX1010, ¶144.) Instead, Spector discloses that the “detection sites for correspondence with individual light spots are defined by the array itself”—*not* by apertures. (EX1005, 3:49-54.)

A POSITA would have understood that Borowski's SPAD arrays would have a “small fill factor” of less than 10% as discussed by Spector. (EX2010, ¶¶145-47.) This is confirmed by a publication from around the priority date of the '405 patent—Sergey L. Vinogradov, “Evaluation of performance of silicon photomultipliers in LIDAR applications” (“Vinogradov”; EX2014). Vinogradov discloses that “[r]egretfully, even mature CMOS technology does not resolve a problem of low fill factor” for a two-dimensional SPAD array. (EX2014 at 3.) Vinogradov discloses that a “recent” SPAD array design resulted in a “fill factor of 3.14%”—*i.e.*, far below

the 10% fill factor cut-off Borowski discusses. (*Id.*) Vinogradov discusses some attempts at addressing the fill factor issue, but each attempt it discusses is associated with other significant issues. (*Id.* at 3-4; EX2010, ¶¶146-47.) Accordingly, Vinogradov ultimately concludes that, “to the best of the author’s knowledge, there are no attempts . . . to combine an array of SPAD arrays . . . as a focal plane array of photon number resolving detectors in 3D imaging LIDARs.” (EX2014 at 4.)

Since a POSITA would have understood that Borowski’s SPAD arrays would have a “small fill factor” of less than 10% as discussed by Spector, a POSITA would not have been motivated to combine Borowski’s SPAD arrays with Spector’s apertures. (EX2010, ¶148.) Spector *only* discloses using apertures with large fill factor detectors. (EX1005, 3:54-56; EX2010, ¶144.) Spector further indicates that “small fill factor” detectors do not need aperture arrays, because “the individual optical detection sites for correspondence with individual light spots are defined by the array itself.” (EX1005, 3:49-54; EX2010, ¶144.) Further, a POSITA would not have had a reasonable expectation of success of increasing the fill factor of SPAD arrays. As Vinogradov confirms, a POSITA would have understood that attempting to increase the fill factor of SPAD arrays would have brought about significant problems that would have undermined any expectation of success. (EX2014 at 3-4; EX2010, ¶¶146-47.)

3. An Ordinarily Skilled Artisan Would Not Have Been Motivated to Combine Hall and Borowski

The sole detector disclosed by Hall for use in its LIDAR system is an avalanche photodiode or APD. (EX1008, 2:10-14 (incorporating by reference U.S. Patent No. 7,969,558); EX2012 (Hall '558), 5:6-7 (“[T]he photo diode is preferably an Avalanche variety, but other types can be used.”), 5:28-31; EX2010, ¶150.) Petitioner’s combination of Hall and Borowski is based on replacing Hall’s APDs with SPAD arrays from Borowski. A POSITA would not have been motivated to replace Hall’s APDs with SPAD arrays, because a POSITA would have understood that Borowski’s noise-prone SPAD arrays would not work in a high-noise system like Hall’s.

As a threshold matter, Petitioner provides no argument or evidence that it would have been obvious to replace Hall’s APDs with Borowski’s SPAD arrays. Instead, Petitioner and its expert ignore Hall’s disclosure of APDs in its system and act as if Hall suggests that any generic detector under the sun could be used in its system. This is incorrect. Hall only discloses the use of *one* type of detector in its system—APDs. (EX1008, 2:10-14; EX2012 (Hall '558), 5:6-7.) Hall discloses that APDs are “preferably” the type of photodetector in its system. (EX2012 (Hall '558), 5:6-7.) And while Hall includes a blanket statement that “other types” of photodiodes can be used in its system, there is no further discussion of photodiode parameters. (*Id.*) Accordingly, the only teaching a POSITA would have been left

with is that APDs or photodiodes *like APDs* should be used in Hall's system. (EX2010, ¶150.)

Since Petitioner and its expert ignore the disclosure of APDs in the Hall system, they fail to provide *any* argument or evidence to suggest that it would have been obvious to a POSITA to *replace* Hall's APDs with Borowski's SPAD arrays. Instead, Petitioner and its expert only seek to support the fact that the use of Borowski's SPAD arrays would have been obvious to use as a photodetector. But that is not the relevant inquiry here. Since Hall discloses using APDs, Petitioner must show that it would have been obvious to replace Hall's APDs with Borowski's SPAD arrays. But Petitioner and its expert have not even attempted to make that showing. Accordingly, as a threshold matter, Petitioner's third and fourth grounds must fail, because there is no evidence to support the obviousness of replacing Hall's APDs with Borowski's SPAD arrays.

Apart from Petitioner's failure of proof as to the combination of Hall and Borowski, the combination must fail, because the evidence indicates that a POSITA would *not* have been motivated to swap Hall's APDs for Borowski's SPAD arrays.

Hall discloses that noise is a problem that must be accounted for in its system. Hall discloses that in LIDAR systems, "[t]he detection of return signals includes significant sources of measurement noise that are exacerbated as measurement ranges are extended." (EX1008, 2:29:31.) Further, Hall discloses using its LIDAR

system in an autonomous vehicle—which, a POSITA would have understood, involves ample noise like competing light sources and temperature fluctuations. (*Id.*, 1:64-2:14; EX2010, ¶¶152-53.) To make matters worse, Hall discloses that using its system in such applications as autonomous vehicles requires “see[ing] over a broad field of view”—meaning that its system will be exposed to more potential sources of noise. (EX1008, 1:65-66.)

Further, a POSITA would have understood that SPADs are highly prone to noise—much more significantly so than APDs. As their names indicate, SPADs (“*single photon* avalanche diodes”) are much more sensitive than APDs (“avalanche photodiodes”), and a POSITA would have understood that SPADs are much more prone to detecting noise as a result. (EX2010, ¶154.) For example, the literature regarding SPADs prior to May 2017 indicate that SPADs are sensitive to ambient light noise; noise associated with tunneling from an electric field; thermally generated noise; afterpulsing noise; optical crosstalk; electrical crosstalk; and electroluminescence from other SPADs. (*Id.*, ¶¶155-57.) Petitioner’s own expert indicates that noise is “particularly problematic” for SPADs, and he discusses differences in operation between SPADs and APDs relevant to the greater sensitivity of SPADs to interference from noise. (EX1003, ¶¶47-56.)

Given the noisy nature of the Hall system and the noise-prone nature of SPADs relative to APDs, a POSITA would not have been motivated to replace the

APDs in Hall's system with the SPAD arrays from Borowski's system. Neither Petitioner nor its expert provides any reason to suggest that a POSITA would have overcome this incompatibility between Hall's system and Borowski's SPADs. For example, neither Petitioner nor its expert point to any other feature or teaching of Borowski that a POSITA would have incorporated into the Hall-Borowski combination to address the noise problem of using SPAD arrays. (EX2010, ¶¶158-59.) Further, neither Hall nor Spector reference SPADs at all—so there cannot be any suggestion that a POSITA would have found teachings in either of these references to suggest that noise-prone SPAD arrays could be used in Hall's high-noise system.

Further, it would not have been obvious to a POSITA how to accommodate the noise-prone nature of SPADs in a noisy spinning LIDAR system like Hall. (EX2010, ¶159.) Dr. Shanley provides general, conclusory statements about techniques related to noise in the abstract. (EX1003, ¶¶51-56.) However, neither Dr. Shanley nor Petitioner provides any evidence as to which, if any, of these techniques would be suitable or sufficient to address noise for SPADs in the context of Hall's spinning LIDAR system. Further, Dr. Shanley only opines as to techniques related to stray light and some types of cross-talk. (*Id.*) But a POSITA would have known about a wide range of noise sources that would need to be addressed for SPADs *other* than stray light—*e.g.*, thermal noise, electroluminance, electrical

cross-talk, optical cross-talk, tunneling, and afterpulsing. (EX2010, ¶¶155-57.)

Since Petitioner provides no evidence to support replacing Hall's APDs with Borowski's SPAD arrays, and because a POSITA would not have considered Borowski's noise-prone SPAD arrays to be combinable with Hall's noisy system, it would not have been obvious to combine Hall and Borowski as Petitioner seeks to argue. Accordingly, Petitioner's grounds 3 and 4—both of which are based on the combination of Hall and Borowski—must fail.

V. SECONDARY CONSIDERATIONS OF NONOBVIOUSNESS

In addition to the arguments and evidence provided above, the patentability of the challenged '405 patent claims over the obviousness combinations asserted in each of Petitioner's grounds is supported by evidence of secondary considerations of nonobviousness. Objective evidence of secondary considerations of nonobviousness includes: (1) commercial success, (2) copying, (3) industry praise, (4) skepticism, (5) long-felt but unsolved need, and (6) failure of others. *See, e.g., Transocean Offshore Deepwater Drilling, Inc. v. Maersk Drilling U.S., Inc.*, 699 F.3d 1340, 1349-56 (Fed. Cir. 2012).

A. Skepticism

The testimony of Petitioner's expert Dr. Shanley supports that there was significant industry skepticism of the use of SPADs in LIDAR systems prior to the '405 patent. (EX2010, ¶¶162-67.)

Dr. Shanley testified that while he was aware of SPADs as of the 1990s, he

never incorporated them into a system, including any of the LIDAR systems he worked on. (EX2011 (Shanley depo transcript), 12:18-22, 14:13-15:4.) For example, Dr. Shanley testified that for one LIDAR system he worked on, he specifically recalls considering using SPADs as the photodetectors in the system—but he ultimately chose to use photodiodes instead of SPADs. (*Id.*, 16:20-17:1.) Dr. Shanley testified that his team rejected SPADs because “[w]e didn’t have the volume and the power required at that point, and we wanted a simple system.” (*Id.*, 17:2-5.) Additionally, Dr. Shanley testified that his team need a photodetector that was “very simple” and “very fast and very quick and very reliable”—and SPADs did not fit the brief. (*Id.*, 18:10-15.) Dr. Shanley testified that his team chose photodiodes instead, because they were “cheap” and an “off-the-shelf array.” (*Id.*, 17:6-12.) In other words, Dr. Shanley testified that though he and his team knew about SPADs prior to the ’405 patent, they did not use SPADs in LIDAR systems due to concerns about their disadvantages, including size requirements, power requirements, complexity, cost, lack of ease of use, lack of reliability, and lack of availability. This is clear evidence that there was significant industry skepticism about the use of SPADs in a LIDAR system, which the challenged claims of the ’405 patent require.

In addition to testifying that his own team never used SPADs in a LIDAR system, Dr. Shanley testified that he was not aware of any LIDAR system, commercial or otherwise, that used SPADs prior to the ’405 patent. (EX2011, 79:2-

80:16.) Coupled with Dr. Shanley’s testimony that SPADs were known as of the 1990s, Dr. Shanley’s testimony about his lack of awareness of SPAD-based LIDAR systems prior to the ’405 patent provides further evidence of skepticism. Dr. Shanley’s testimony indicates that between the 1990s and 2017—a period of around 25 years—SPADs were available and known but practitioners avoided using them in LIDAR systems. This strongly suggests that the industry harbored strong skepticism about SPADs prior to the ’405 patent.

B. Failure of Others

Publications from the period the priority date of the ’405 indicate that many had sought—but failed—to develop arrays of SPADs for use in LIDAR systems. (EX2010, ¶168.) For example, Sergey L. Vinogradov, “Evaluation of performance of silicon photomultipliers in LIDAR applications” (“Vinogradov”; EX2014), which was published right around the May 15, 2017 priority date of the ’405 patent, discusses repeated failures of researchers to develop practical SPAD arrays.

Vinogradov indicates that researchers sought to develop “front-side SPAD arrays,” but these had “a problem of a low fill factor (ratio of sensitive area to the total area occupied by electronics for active quenching of Geiger discharge)[.]” (EX2014 at 3.) Vinogradov indicates that researchers sought to eliminate the fill-factor problem by using backside illuminated SPAD technology, but “[r]egretfully,” this “introduced prohibitively high dark count rate (DCR)[.]” (*Id.*) Vinogradov

indicates that another approach pursued by researchers is to use a digital SiPM (dSiPM). (*Id.* at 4.) However, Vinogradov indicates that “dSiPM technology is rather expensive and inflexible in scaling of the dSiPM dimensions and especially in producing arrays of dSiPMs due to large periphery occupied by electronics.” (*Id.*) Having recounted the failures of these various approaches to SPAD arrays, Vinogradov concludes “[t]o the best of the author’s knowledge, there are **no attempts** either to implement SPAD arrays or dSiPMs as a single photon number resolving LIDAR receiver or to combine an array of SPAD arrays or dSiPMs as a focal plane array of photon number resolving detectors in 3D imaging LIDARs.” (*Id.* at 4 (emphasis added).)

Vinogradov shows that researchers repeatedly failed to develop SPAD arrays usable in a LIDAR system prior to the ’405 patent. Since the challenged claims all require photosensors comprised of a plurality of single photon avalanche diodes (SPADs), the failure of others that Vinogradov describes provides strong support that the challenged claims are not obvious over the prior art. (EX2010, ¶¶168-70.)

VI. CONCLUSION

Based on the arguments and evidence provided above, the Board should find claims 21 or 23-34 of the ’405 patent patentable over the instituted grounds.

Dated: June 25, 2024

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CERTIFICATE OF COMPLIANCE WITH WORD COUNT

Pursuant to 37 C.F.R. § 42.24(d), I certify that this petition complies with the type-volume limits of 37 C.F.R. § 42.24(a)(1)(i) because it contains 11,426 words, according to the word-processing system used to prepare this petition, excluding the parts of this petition that are exempted by 37 C.F.R. § 42.24(a) (including the table of contents, a table of authorities, mandatory notices, a certificate of service or this certificate word count, appendix of exhibits, and claim listings).

DATED: June 25, 2024

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CERTIFICATE OF SERVICE

I hereby certify, pursuant to 37 C.F.R. Sections 42.6 and 42.105, that a complete copy of the attached **PATENT OWNER RESPONSE**, including all exhibits (**Nos. 2010-2016**) and related documents, are being served via electronic mail on the 25th day of June 2024, upon Petitioner by serving Petitioner's counsel of record as follows:

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