UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HESAI TECHNOLOGY CO., LTD.
Petitioner

v.

OUSTER, INC.
Patent Owner

Case IPR 2023-01457
U.S. Patent No. 11,190,750
Issue Date: November 30, 2021

Title: OPTICAL IMAGING SYSTEM WITH A PLURALITY OF SENSE CHANNELS

DECLARATION OF JASON A. JANÉT, PH.D.

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EXHIBIT LIST

EXH. NO.	DESCRIPTION
2001	Respondent's Proposed List of Terms to be Construed dated June 21, 2023, in ITC Inv. No. 337-TA-1363
2002	Respondent's Proposed Claim Constructions dated June 28, 2023, in ITC Inv. No. 337-TA-1363
2003	Respondent's Proposed List of *Markman* Exhibits dated July 13, 2023, in ITC Inv. No. 337-TA-1363
2004	Excerpts from Rudolf F. Graf, *Modern Dictionary of Electronics* (7th ed. 1999)
2005	Excerpts from Frank Pedrotti, *Introduction to Optics* (3d ed. 2006)
2006	Excerpts from Ulrich Kubitscheck, *Fluorescence Microscopy, From Principles to Biological Applications* (2d ed. 2017)
2007	Biography of Patrick W. Lauppe
2008	Declaration of Patrick W. Lauppe ISO Motion for *Pro Hac Vice* Admission
2010	Transcript of James F. Shanley, Ph.D., deposition dated June 28, 2024
2011	The Oxford English Dictionary (2d Ed., Vol. III), Cham-Creeky (1989) (excerpts)
2012	Sergey L. Vinogradov, "Evaluation of performance of silicon photomultipliers in LIDAR applications" (2017)
2013	Edoardo Charbon et al, "SPAD-Based Sensors" (2013)
2014	Cristiano Niclass, et al, "A Single Photon Avalanche Diode Array Fabricated in Deep-Submicron CMOS Technology" (2006)

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EXH. NO.	DESCRIPTION
2015	Transcript of James F. Shanley, Ph.D., deposition dated June 6, 2024
2016	Transcript of Michael Stephen Lebby, Ph.D., deposition in IPR2023-01422 dated May 23, 2024
2017	Hesai Technology Co., Ltd.'s Petition in IPR2023-01422, dated September 14, 2023
2018	Declaration of James F. Shanley, Ph.D., in IPR2023-01456, dated September 25, 2023 (excerpts)

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I. BACKGROUND AND QUALIFICATIONS

1. My name is Jason Janét. I have prepared this declaration as an expert witness on behalf of Ouster, Inc ("Ouster"). I have been retained by Ouster at my standard rate of $475. In this declaration, I provide my opinion as to whether claims 44-48 and 50 of U.S. Patent No. 11,190,750 (the "'750 patent") (**EX1001**) are valid in light of certain alleged prior art references. I also provide herein the technical bases for these opinions, as appropriate.

2. My credentials are set forth in full detail in my Curriculum Vitae which is attached as Exhibit A, incorporated here by reference, and summarized as follows: I am currently CTO for Applied Research Associates (ARA). I also hold the rank of Adjunct Associate Professor at Duke University and at North Carolina State University.

3. I received a Bachelor of Science in Mechanical Engineering from the University of Virginia in 1990; a Master of Integrated Manufacturing Systems from the Integrated Manufacturing Systems Engineering Institute at North Carolina State University in 1994; and a Ph.D. in Electrical and Computer Engineering from North Carolina State University in 1998.

4. Since 1991, I have been active in the robotics, sensors, artificial intelligence, pattern analysis, and automation fields. My MS thesis, entitled *Global Motion Planning and Self-Referencing for Autonomous Mobile Robots*, leveraged

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graph theory and time-of-flight and/or Doppler sensors to optimize mobile robot movement through, and perception of, environments. My PhD dissertation, entitled *Pattern Analysis, Tracking and Control for Autonomous Vehicles,* leveraged multiple UGVs, time-of-flight and/or Doppler sensors, point clouds, and neural networks to enhance simultaneous localization and mapping (SLAM), as well as the sharing of knowledge between multiple different UGVs. I have authored numerous publications and have co-authored a textbook entitled *Computational Intelligence*.

5. I have designed, built, and marketed toys, robots, automated systems, measuring systems and components thereof, including ground mobile robots, unmanned aerial vehicles (UAV), unattended sensors, automated storage and retrieval systems (ASRS), submersible mobile robots, proof-of-concept extra-terrestrial robots, manually-manipulated ("twiddled") submersible foils, wall climbing mobile robots, corner-grip ballgame goals, proximity and ranging systems, point-cloud systems, pattern analysis tools, and augmented reality systems.

6. I have taught the following courses: Introduction to Robotics and Automation (Duke and NCSU); Introduction to Control Theory (Duke and NCSU); Distributed Real-Time Controls (NCSU); and myriad independent studies courses in the areas of robotics, automation, artificial intelligence, autonomy, pattern analysis, sensors, and control systems. I have also served on several MS- and PhD-level graduate student committees, designed qualifying exam problems, served on

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the NCSU IMSEI Board, and participated in curriculum development for undergraduate and graduate level programs.

7. I have also started, sponsored, and advised multiple champion student teams for international robot competitions including, but not limited to, the NASA/ASCE Extra-Terrestrial Robotics Competition, the DARPA Grand Challenge, the AUVSI/ONR Autonomous Underwater Vehicle Competition, and the European CLAWAR Wall-Climbing Robot competition.

8. I have initiated multiple unmanned systems projects at both academic and industry levels. Academic unmanned aerial vehicles (UAVs) include, but are not limited to, Quadcopters with Hybrid Remote and Autonomous Control, Marsupial UAVs that Deploy and Recover Unmanned Ground Vehicles, and Wall-Climbing UAVs. Additionally, the AngelFish Cross-Domain Submersible UAV, a DARPA ASW program that I incubated and procured funding for at Teledyne, included a partnership with North Carolina State University. Unmanned underwater vehicles (UUVs) include, but are not limited to, the MicroHunter-class of very small underwater robots, the PilotFish, Gamera, Artemis and other holonomic robots, and submersible crawlers that are used in nuclear boiler water reactors, the LBC hull inspection system, and the HULLBUG hull cleaning system. Unmanned ground vehicles (UGVs) include, but are not limited to, the miniature PERRY, wall-climbers, all-terrain and subterranean crawlers.

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9. I have also supported multiple toy-focused ventures with companies including, but not limited to, Marvel, Hasbro, Twidco, Spin Master, Nottingham-Spirk, IDEO, ARA, and other firms. For Marvel, multiple Spiderman toys were conceived and developed and validated, including the Spiderman Wall-Climbing Car, the Corner-Climbing Spider, and the Inflatable Wall-Climbing Spiderman. For Hasbro, a proprietary corner-gripping technology was employed to place basketball goals in corners. For Twidco, a proprietary flapping foil technology was combined with multiple fish shapes (e.g., shark and clownfish) to enable users to create fish-like motion by "twiddling" a connecting cable from above. For Spin Master and multiple design firms, multiple wall-climbing toys were developed for small wall-climbing robot concepts including simple radio control vehicles and the "Hangtime 540" Tony Hawk aerial skateboard toy. For ARA, augmented reality systems for indoor and outdoor games.

10. In 1999, while I was employed by Nekton Research ("Nekton"), I captured and managed multiple programs sponsored by the Department of Defense (DoD) and private-sector companies that focused primarily on autonomous underwater vehicles (AUV), remotely operated vehicles (ROV), TwiddleFish toys, and indirect-fire projectiles. During my tenure, Nekton entered into a joint venture agreement with the founders of what eventually became known as Parata Systems – a pharmacy automation solutions company, which I supported launching.

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11. After leaving Nekton in March 2002, I joined a then New Jersey-based company called Avionic Instruments, Inc ("Avionic"). While at Avionic, I continued developing and marketing robots and supported engineering related to various design, manufacturing, quality and assembly issues on the core aerospace product lines. Avionic product lines include, but are not limited to, ducted fans, transformer-rectifier units (TRU), regulated TRU (RTRU), auxiliary power unit (APU) control systems, power distribution systems (PDU), frequency converters, corner clamps, and VRAM attractors/thrusters. Customers included DoD, NASA, Boeing, Sikorsky, Augusta-Westland, Dassault, and Lockheed-Martin.

12. At Avionic, I was also tasked with ruggedizing, optimizing, and commercializing two emerging proprietary technologies: the "CFG" and "VRAM". The CFG, short for Corner Friction Grip, was a proprietary technology based on non-marring and non-adhesive materials that provided optimal grip patterns on inside and outside corners. CFG formed the basis of a company called "Shelf Works Technologies," which was spun out of Avionic instruments in 2004, and whose products were sold in Home Depot, Bed Bath and Beyond, etc. CFG also formed the basis of multiple toys including a miniature basketball goal for Hasbro, and a corner climbing Spiderman toy for Marvel.

13. The VRAM, short for Vortex Regenerative Air/Aqueous Movement is a patented method for producing attraction forces between an object and a surface.

VRAM is euphemistically referred to as a "tornado in a cup" and generally comprises both cylindrical and toroidal flow patterns that result in vacuum-like regions. The VRAM had several applications, including but not limited to: holding breaching charges and sensors against vertical or inverted surfaces; acting as an attractor for wall and ceiling climbing robots; acting as an attractor for submersible hull-crawling robots; filter-less vacuuming (conceptually similar to the Dyson vacuum); and robotic pick-and-place end-effector (conceptually similar to a gripper) to move articles from one location (e.g., a conveyor) to another (e.g., a collator). The VRAM also formed the basis for multiple toys including: a wall-climbing car for Spin Master, IDEO and Nottingham-Spirk; a Spiderman car for Marvel; an inflatable wall-climbing Spiderman for Marvel; and the Tony Hawk Hangtime 540 aerial skateboard for IDEO.

14. My work with the filter-less vacuum VRAM prompted me to explore a concept related to pharmacy automation, which ultimately led to a Ferris-wheel concept for rapidly dispensing pills. In mid-2003, my team conceived of two prescription pill counting mechanisms that actually benefitted from centrifugal forces and optimally exploited gravity and vacuum: an inner ring with vacuum-based apertures and an inner-bowl with vacuum-based apertures. The inner-bowl with vacuum-based apertures was deemed most viable, was awarded two US patents, and to this day forms the basis of the RxMedic ADS™ pharmacy robot. The VRAM

formed the basis of Vortex HC technologies, many of which have been licensed out to entities including, but not limited to Teledyne SeaBotix, SeaRobotics, and HDT. Both RxMedic and Vortex HC were officially spun out of Avionic in July 2004, at the date Avionic was acquired by Transdigm.

15. In late 2004, soon after Avionic was acquired, I, along with others from Avionic, secured funding to develop an alpha-level multi-dispenser pharmacy robotic system and develop the RxMedic business plan and raise multiple rounds of venture capital. In late 2006, RxMedic (called "APDS" until November 2006) was launched as a stand-alone, sole-focus venture. After the operational launch of RxMedic, I served as General Manager and eventually Chief Technical Officer. Through my roles at RxMedic, I oversaw the development of the RxMedic ADS robot, managed the intellectual property portfolio, coordinated sales and marketing, and provided strategic, fiscal, and operational leadership. In May 2010, J.M. Smith Corporation acquired RxMedic, and to assist in the change of ownership, I served as a Director of RxMedic until May 2011.

16. Also in late 2004, after Avionic was acquired, I, along with others from Avionic, secured funding for Vortex HC through DoD contracts and robot sales, to continue developing the VRAM Mobile Robot Platform (VMRP – a wall-climbing robot), the ARTEMIS AUV (a holonomic submersible robot for counter-mine and counter-obstacle operations), the submersible crawler, the nuclear-grade boiler

water reactor (BWR) inspection robot, and other robot products centered around the VRAM. Some DoD programs were/are classified, for which I maintained a SECRET clearance at both the personal and facilities level, and served as the facilities security officer (FSO). In late 2006, corresponding to the full launch of RxMedic, Vortex HC technologies were largely licensed to Teledyne SeaBotix, SeaRobotics, and HDT. However, I have continued to support Vortex HC licensees and customers to-date.

17. After the sale of RxMedic, and after fulfilling my 12-month employment obligation, I joined Teledyne Technologies in Summer 2011. I served as the Senior Manager for the RTP division of Teledyne Scientific, and supported multiple DoD-sponsored robotic-focused programs. Some of these programs were/are classified, for which I maintained a personal SECRET clearance. Among these programs, were cargo unmanned ground vehicles (CUGV); squad-level autonomous unmanned ground vehicles (UGV); autonomous underwater vehicles (AUV); unmanned underwater vehicles (UUV); a cross-domain autonomous vehicle capable of transitioning between air-, surface- and underwater-domains; the EXACTO program for optically tracking and steering bullets to targets; and LIDAR systems for UGVs, as well as the mapping of urban and subterranean environments (along with sister-company Optech). Cross-domain vehicles that were evaluated, designed and prototyped included, but were not limited to, the AngelFish (later

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called “EagleRay”) cross-domain submersible UAV for anti-submarine warfare, as well as a ball-shaped robot for beach-, ground- and surf-zone countermine operations. Sensor design, refinement and signal processing was a major component of each program. Sensors employed include, but are not limited to: proximity sensors; ranging sensors; electro-optical imaging; LIDAR. long-, short- and mid-wave infrared (IR); inertial measurement units (IMU); optical flow; and radio-frequency (RF). Additionally, control systems were designed, refined and integrated into the aforementioned systems. Most control systems were closed-loop, in that they utilized sensor-based feedback; others were open-loop, where states were estimated with little or no feedback.

18. In late 2013, Avionic, a Transdigm business unit at that point, requested that I return to turn around both a supply-chain issue, and the Sikorsky S97 Raider/JMR helicopter programs. The S97 Raider was designed to be the fastest, most maneuverable helicopter, due to its coaxial, counter-rotating variable-pitch wings, and an aft-based push-propeller. Avionic also controlled two business units named Acme Aerospace (Acme) and Aerospace Cooling Solutions (ACS). Avionic, Acme and ACS supported the S97 program, which ultimately met milestones and continues to produce multiple successful demonstrations. In 2013, Transdigm expanded my role to include directorship of the Avionic, Acme and ACS revenue and engineering teams, and to report operational and financial status at six-week

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intervals. Transdigm required that I move my family to New Jersey in late 2014, which influenced my decision to resign and assume the CEO role offered to me by Delta Five Systems in Raleigh, NC.

19. As CEO of Delta Five, I led a private-equity backed, hospitality-focused venture, coordinating the company's launch and strategic path including an early-stage pivot. Initially focused on back-end robotics and automation, Delta Five shifted its focus to address the rampant bed bug problem—a top priority for hoteliers—with a novel unattended sensor and trap, called the Telemetered Pest Monitoring System (TPMS), which is based on computer vision and internet of things (IoT), and has proven capable of scaling to other pests. In addition to the TPMS, Delta Five developed a novel means to mass produce a natural, unscented aggregation pheromone that, in concert with placement and heat, lured invertebrates to the TPMS. After leading Delta Five and serving on its Board for four years, I resigned to join ARA, but continue serving Delta Five as a share-holder and transition agent.

20. In 2018, I joined ARA as CTO. My primary responsibilities include leading the commercialization and technology transition efforts, which require technical, business and corporate development, as well as the procurement of capital and managing matrixed rosters.

21. I have served as an expert witness on multiple cases including cases

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involving IPR, ITC, contract disputes, and civil litigation in District and Federal Courts. My resume lists these cases.

22. In formulating my opinions, I have relied upon my training, knowledge, and experience in the relevant art.

II. LEGAL STANDARDS

23. In formulating my opinions and conclusions in this proceeding, I have been provided with an understanding of the prevailing principles of U.S. patent law that govern the issues of patent validity.

A. Claim Construction

24. I understand that the purpose of claim construction is to determine what a person of ordinary skill in the art would have understood the claim terms to mean. Claim terms are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art in question as of the effective filing date.

25. I understand that the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification. I understand that the patent specification, under the legal principles, has been described as the single best guide to the meaning of a claim term, and is thus highly relevant to the interpretation of claim terms. And I understand for terms that do not

have a customary meaning within the art, the specification usually supplies the best context of understanding the meaning of those terms.

26. I further understand that other claims of the patent in question, both asserted and unasserted, can be valuable sources of information as to the meaning of a claim term. Because the claim terms are normally used consistently throughout the patent, the usage of a term in one claim can often illuminate the meaning of the same term in other claims. Differences among claims can also be a useful guide in understanding the meaning of particular claim terms.

27. I understand that the prosecution history can further inform the meaning of the claim language by demonstrating how the inventors understood the invention and whether the inventors limited the invention in the course of prosecution, making the claim scope narrower than it otherwise would be. Extrinsic evidence, such as dictionaries, may also be consulted in construing the claim terms.

28. I understand that, in *Inter Partes* Review (IPR) proceedings, a claim of a patent shall be construed using the same claim construction standard that would be used to construe the claim in a civil action filed in a U.S. district court (which I understand is called the "*Phillips*" claim construction standard), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

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29. I have been instructed by counsel to apply the "*Phillips*" claim construction standard for purposes of interpreting the claims in this proceeding, to the extent they require an explicit construction. The description of the legal principles set forth above thus provides my understanding of the "*Phillips*" standard as provided to me by counsel.

30. I understand that certain terms appearing in the challenged claims have been the subject of dispute in an ITC proceeding.

31. I understand that the parties have proposed claim constructions for various terms of the challenged claims in an ITC proceeding. I also understand that no claim construction has taken place in that proceeding.

32. Where claim construction issues arise, I have noted them in my analysis below.

B. Anticipation

33. I am informed and understand that to anticipate a patent claim under 35 U.S.C. § 102, a single asserted prior-art reference must disclose each and every element of the claimed invention, either explicitly or inherently, to a person of ordinary skill in the art. There must be no difference between the claimed invention and the disclosure of the alleged prior-art reference as viewed from the perspective of the person of ordinary skill in the art.

34. Also, I understand that for a reference to be an anticipating reference,

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it must describe the claimed subject matter with sufficient clarity to establish that the subject matter existed and that its existence was recognized by persons of ordinary skill in the field of the invention.

35. In addition, I am informed and understand that to establish that an element of a claim is "inherent" in the disclosure of an asserted prior-art reference, the extrinsic evidence (or the evidence outside the four corners of the asserted prior-art reference) must make clear that the missing element is the inevitable outcome of the process and/or thing that is explicitly described in the asserted prior-art reference, and that it would be recognized as necessarily present by persons of ordinary skill in the relevant field.

C. Obviousness

36. I am also informed and understand that even though a prior-art reference does not fully anticipate a claim of a patent, a claim may nonetheless be rendered obvious to a person of ordinary skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the subject matter as a whole of the claim would have been obvious at the time the claimed invention was made.

37. I am informed and understand that obviousness is a determination of law based on various underlying determinations of fact. In particular, these underlying factual determinations include (1) the scope and content of the prior art;

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(2) the level of ordinary skill in the art at the time the claimed invention was made; (3) the differences between the claimed invention and the prior art; and (4) the extent of any proffered objective *indicia* of nonobviousness. I understand that the objective *indicia* which may be considered in such an analysis include commercial success of the patented invention (including evidence of industry recognition or awards), whether the invention fills a long-felt but unsolved need in the field, the failure of others to arrive at the invention, industry acquiescence and recognition, initial skepticism of others in the field, whether the inventors proceeded in a direction contrary to the accepted wisdom of those of ordinary skill in the art, and the taking of licenses under the patent by others, among other factors.

38. I am informed and understand that to ascertain the scope and content of the prior art, it is necessary to first examine the field of the inventor's endeavor and the particular problem for which the invention was made. The relevant prior art includes prior art in the field of the invention, and also prior art from other fields that a person of ordinary skill in the art would look to when attempting to solve the problem.

39. I am informed and understand that a determination of obviousness cannot be based on the hindsight combination of components selectively culled from the prior art to fit the parameters of the patented invention. Instead, it is my understanding that to render a patent claim invalid as being obvious from a

combination of references, there must be some evidence within the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination in a way that would produce the patented invention.

40. I am further informed and understand that in an obviousness analysis, neither the motivation nor the purpose of the patentee dictates. What is important is whether there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims.

41. In addition, it is my understanding that to find a patent claim invalid for obviousness, there must be a finding that each element in each limitation of the patent claim is disclosed, taught, or suggested by the asserted combination of prior-art references or elsewhere in the relevant prior art. I understand, however, that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. But multiple prior-art references or elements may, in some circumstances, be combined to render a patent claim obvious. I understand that I should consider whether there is an "apparent reason" or motivation to combine the prior-art references or elements in the way the patent claims. To determine whether such an "apparent reason" or motivation exists to combine the prior-art references or elements in the way a patent claims, it will often be necessary to look to the interrelated teaching of multiple prior-art references, to the effects of demands

known to the design community or present in the marketplace, and to the background knowledge possessed by a person of ordinary skill in the art.

42. I also understand that when the prior art "teaches away" from combining prior-art references or certain known elements, discovery of a successful means of combining them is more likely to be nonobvious. A prior-art reference may be said to "teach away" from a patent when a person of ordinary skill in the art, upon reading the reference, would be discouraged from following the path set out in the patent or would be led in a direction divergent from the path that was taken by the patent. Additionally, a prior-art reference may "teach away" from a claimed invention when substituting an element within that prior-art reference for a claim element would render the claimed invention inoperable.

43. I am informed and understand that a patent for a combination which only recites old elements with no change in their respective functions withdraws what is already known into the field of its monopoly and diminishes the resources available to person of ordinary skill in the field. When a patent claims a structure already known in the prior art that is altered by mere substitution of one element for another known in the field, the combination must do more than yield a predictable result. I am informed and understand that the corollary to this principle is that when the prior art teaches away from combining known elements, discovery of a successful means of combining them is more likely to be nonobvious. Thus, the

question to be answered is whether someone reading the prior art would be discouraged from following the path taken by the inventor.

44. I am further informed and understand that when an element is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation of that available element, Section 103 likely renders the invention obvious. For the same reason, I am informed and understand that if a technique has been used to improve one device or process, and a person of ordinary skill in the art would recognize that such technique would improve similar devices or processes in the same way, using the technique is obvious unless its actual application is beyond his or her skill. Following these principles often requires one to look to interrelated teachings of multiple patents; the effects of demands known to the design community present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art to determine whether there was an apparent reason to combine the known element in the manner claimed by the patent at issue. I am further informed and understand that the analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, because one can take account of the inferences and creative steps that a person of ordinary skill in the art would employ.

45. I am further informed and understand that although the use of the

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"teaching, suggestion or motivation" test for combining references has not been completely rejected, the obviousness analysis cannot be confined by a formalistic conception of the words teaching, suggestion, and motivation, or by overemphasis on the importance of published articles and the explicit content of issued patents. Under the correct analysis, any need or problem known in the field of endeavor at the time of the invention and addressed by the patent can provide a reason for combining the elements in the manner claimed. Finally, I am informed and understand that common sense teaches that familiar items may have obvious uses beyond their primary purposes and, in many cases, a person of ordinary skill in the art will be able to fit the teachings of multiple patents together like pieces of a puzzle.

D. Written Description

46. I understand that one requirement of a patent's disclosure is that the patent's specification must meet the "written description" requirement of § 112 paragraph 1.

47. To have an adequate written description, I understand the patent must convey with reasonable clarity to one skilled in the art that, as of the filing date sought, the patentee was in possession of the invention.

48. To demonstrate possession of the invention, I understand the specification must permit a person of ordinary skill in the art to recognize the subject matter purportedly described. Although the specification need not describe the

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claimed subject matter verbatim to demonstrate possession of the invention, generalized language will not suffice if it does not convey the detailed identity of an invention.

49. To have an adequate written description, each element of the claimed invention must be actually or inherently disclosed in the specification; it is not sufficient that the specification may render the claim element obvious to a person of ordinary skill in the art.

50. In addition, the patent's specification must contain sufficient written description so that a person of ordinary skill in the art would have had reasonable certainty as to the process and manner of making and using the alleged invention.

E. Enablement

51. In addition to the written description requirement, I understand that a patent's specification must describe the claimed invention in such full, clear, concise, and exact terms as to enable one of ordinary skill in the art to make and use the full scope of the claimed invention without undue experimentation. I also understand that in determining whether a patent meets this requirement, one considers the level of ordinary skill in the art as of the priority date of the patent. I further understand that a claim is invalid if it is not supported by an enabling disclosure as of the alleged priority date.

52. I further understand that the fact that some experimentation may be

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required for one of ordinary skill in the art to practice the claimed invention does not necessarily mean the patent fails to meet the enablement requirement. However, it is my understanding that the factors that may be considered in determining whether undue experimentation would be required to make and use the claimed invention include: the quantity of experimentation necessary, the amount of direction or guidance disclosed in the patent, the presence or absence of working examples in the patent, the nature of the invention, the state of the prior art, the relative skill of those in the art, the predictability of the art, and the breadth of the claims.

53. It is further my understanding that a patent need not expressly state information that skilled persons would be likely to know or could obtain.

54. I understand that the full scope of the claims must be enabled, such that the scope of the claimed invention is not greater than the scope of the invention enabled by the specification. I further understand that elements of a claim may not be enabled when the inventor was not able to implement the elements at the time of filing.

55. It is also my understanding that a patent can lack enablement of a given claim element by expressly teaching away from it.

F. Priority Date

56. I understand that the "priority date" of an invention is the date that determines whether a reference qualifies as prior art to the alleged invention. I

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understand that the priority date is the date the patent application is filed, and that a patent application may claim priority to an earlier-filed application or applications. In order to successfully claim priority to an earlier-filed application, the earlier-filed application must provide (i) sufficient written description support and (ii) an enabling disclosure for the full scope of the later-claimed invention. If the earlier-filed application fails to provide sufficient written description or lacks an enabling disclosure for the full scope of the later-claimed invention, the patent is not entitled to the priority date of the earlier-filed application.

III. MATERIALS REVIEWED

57. As noted above, I have reviewed a number of materials in rendering the opinions in this Report. In preparing this declaration, I have considered the claims, specification, and prosecution history of the '750 patent. I have reviewed the Petition for *Inter Partes* Review (and exhibits, including the Declaration of James F. Shanley) filed by Petitioner Hesai Technology Co., Ltd. filed on September 25, 2023; Ouster's Patent Owner Preliminary Response (and exhibits) filed on January 3, 2024; and the Board's Institution Decision issued April 1, 2024. I have also reviewed the deposition transcript (and exhibits) in this proceeding (and the co-pending IPR2023-01456) of Dr. James F. Shanley, dated June 28, 2024. To the extent that materials cited in this declaration are not reflected in the above paragraph, I have also relied on any materials cited in this declaration in rendering my opinions.

IV. PERSON OF ORDINARY SKILL IN THE ART

58. I am informed and understand that the claims of a patent are judged from the perspective of a hypothetical construct involving a "person of ordinary skill in the art." The "art" is the field of technology to which the patent is related. I understand that the purpose of using the viewpoint of a person of ordinary skill in the art is for objectivity. I understand that a person of ordinary skill in the art is presumed to know and be familiar with the relevant art in the field at the time of invention and is also presumed to possess an average level of creativity.

59. I understand that factors that may be considered in determining the level of ordinary skill include: (1) the type of problems encountered in the art at or prior to the relevant time period; (2) pre-existing solutions (i.e., prior art) to those problems; (3) the pace at which solutions innovations were developed at the relevant time period; (4) the sophistication of technology at the relevant time period; and (5) the education level of people working in the relevant field(s) at the relevant time period.

60. In my opinion, 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. My opinion as to a POSITA is based on my relevant academic and industry experience.

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61. I have applied this level of skill to my analysis in this case. Based on my education and experience, I consider myself to have at least the necessary qualifications of a POSITA and have prepared all opinions set forth herein on the basis of that understanding. Furthermore, I frequently interact with, work with, supervise, and mentor persons with these qualifications.

62. I understand that Dr. Shanley asserted that a POSITA would have had "an undergraduate degree in mechanical or electrical engineering or physics and two to three years of experience in the field of LiDAR design. I disagree with Dr. Shanley's additional requirements related to LIDAR system design. In my opinion, a POSITA need only have at least one year of work experience with LIDAR designs—and another two to three years of work experience with electro-optical and electro-mechanical devices or systems. Given the '750 patent's focus on optical and mechanical aspects of the design of its disclosed systems, two to three years of work experience with electro-optical and electro-mechanical systems would have been sufficient for a POSITA in my opinion.

V. THE '750 PATENT

A. Summary

63. U.S. Patent No. 11,190,750 B2 (the "'750 patent"), titled "Optical Imaging System with a Plurality of Sense Channels," was filed on July 26, 2018, granted November 30, 2021, and claims priority to provisional application

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No. 62/232,222, filed on September 24, 2015.

64. Figure 1 of the ’750 patent is reproduced below:

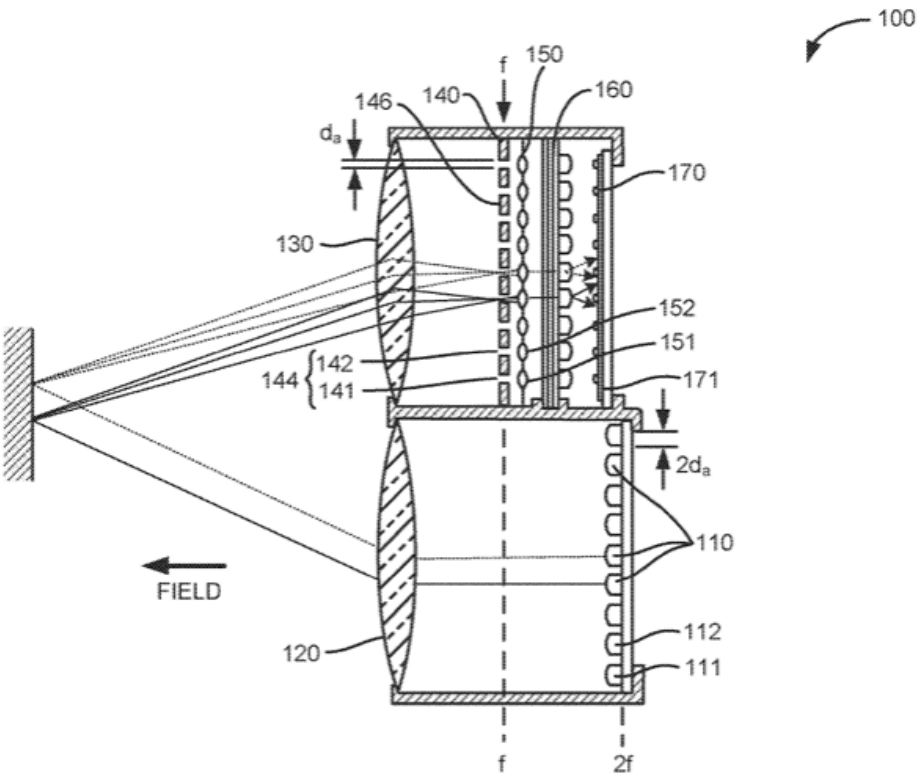


FIG. 1

(EX1001, FIG. 1.) Illumination sources **110** are “arranged along a first axis” and emit light through bulk transmitting optic **120**. (*Id.*, 1:66-2:3.) The illumination sources are “configured to output an illuminating beam of an operating wavelength toward a discrete spot in the field ahead of the illumination source.” (*Id.*) Light reflected by the external field returns to the system through “bulk imaging optic **130** characterized by a focal plane opposite the field.” (*Id.*, 2:3-4.) Then, light enters through a set of apertures **144**, lenses **150**, optical filter **160** “configured to pass light

rays at the operating wavelength," and are directed by diffusers **180** onto pixels **170** for detection. (*Id.*, 2:4-29.)

65. The '750 patent discloses that its system can "selectively project illuminating beams into a field ahead of the system according to an illumination pattern that substantially matches—in size and geometry across a range of distances from the system—the fields of view of the apertures." (*Id.*, 2:58-62.) "In particular, the illumination sources are configured to illuminate substantially only surfaces in the field ahead of the system that can be detected by pixels in the system such that minimal power output by the system (via the illumination sources) is wasted by illuminating surfaces in the field for which the pixels are blind." (*Id.*, 2:62-3:1.) "The system can therefore achieve a relatively high ratio of output signal (i.e., illuminating beam power) to input signal (i.e., photons passed to an incident on the pixel array)." (*Id.*, 3:1-3.)

66. The aperture layer **140** is made up of a set of apertures **144**, each of which "defines a field of view in the field coincident a discrete spot output by a corresponding illumination source in the set of illumination sources **110**." (*Id.*, 3:52-63.) The aperture layer includes stop regions **146**, which "absorb[] and/or reflect[] light rays reflected from surfaces in the field outside of fields of view defined by the set of apertures **144**[.]" (*Id.*, 3:60-63.) "The aperture layer **140** includes a relatively thin opaque structure coinciding with (e.g., arranged along) the focal plane of the

bulk imaging optic **130**[.]" (*Id.*, 4:6-9.)

67. The pixel array "includes a set of pixels **170** adjacent the optical filter **160** opposite the set of lenses **150**, each pixel in the set of pixels **170** corresponding to a lens in the set of lenses **150** and including a set of subpixels arranged along a second axis non-parallel to the first axis." (*Id.*, 8:43-47.) "In one implementation, a first pixel **171** in the set of pixels **170** includes an array of single-photon avalanche diode detectors (hereinafter 'SPADs'), and the diffuser **180** spreads lights [sic] rays—previously passed by a corresponding first aperture **141**, collimated by a corresponding first lens **151**, and passed by the optical filter **160**—across the area of the first pixel **171**[.]" (*Id.*, 9:1-7.)

68. The illumination sources **110** "can include a monolithic VCSEL arrays including a set of discrete emitters. In this implementation, the bulk transmitter optic can be substantially identical to the bulk imaging optic **130** in material, geometry (e.g., focal length), thermal isolation, etc., and the bulk transmitter optic is adjacent and offset laterally and/or vertically from the bulk imaging optic **130**." (*Id.*, 10:67-11:7.)

B. Challenged Claims

69. I understand that Petitioner is challenging claims 44-48 and 50 of the '750 patent, reproduced below:

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Claim 44
44(a) An optical imaging system comprising:
44(b) a bulk imaging optic;
44(c) a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel;
44(d) an aperture layer disposed between the bulk imaging optic and the plurality of pixels, the aperture layer comprising a plurality of apertures separated from each other by a stop region, the plurality of apertures including a first aperture disposed in a first optical path extending between the bulk imaging optic and the first pixel and a second aperture disposed in a second optical path extending between the bulk imaging optic and the second pixel;
44(e) a bulk transmitting optic disposed adjacent to the bulk imaging optic; and
44(f) a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels.
Claim 45
The optical imaging system of claim 44 wherein the plurality of pixels further includes third and fourth pixels, and the plurality of apertures further includes a third aperture disposed in a third optical path extending between the bulk imaging optic and the third pixel and a fourth aperture disposed in a fourth optical path extending between the bulk imaging optic and the fourth pixel.
Claim 46
The optical imaging system of claim 44 wherein the plurality of emitters comprises a plurality of vertical-cavity surface-emitting lasers (VCSELs).
Claim 47
The optical imaging system of claim 46 wherein each emitter in the plurality of emitters comprises a single VCSEL.
Claim 48
The optical imaging system of claim 44 wherein each pixel in the plurality of pixels is operable to output a signal corresponding to a count of photons incident on the pixel within one sample period.

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Claim 50
The optical imaging system of claim 44 wherein the optical imaging system is configured to collect distance data based on recorded times between transmission of beams of electromagnetic radiation emitted from the plurality of emitters and detection of photons originating from the beams of electromagnetic radiation.

VI. DR. SHANLEY'S ASSERTED PRIOR ART

70. Below are summaries of the prior art Dr. Shanley is asserting in this IPR that I discuss at length in this declaration.

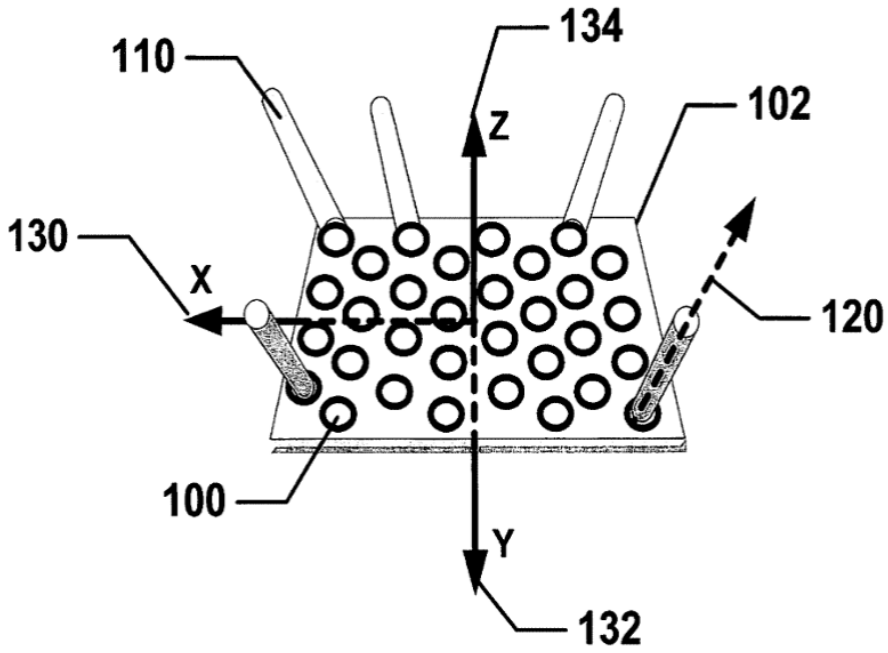
A. Retterath

71. U.S. Patent No. 10,203,399 B2 ("Retterath") is a patent that discloses "LiDAR (light detection and ranging) systems" that "use an array of emitter/detector sets to cover a given field of view where each emitter/detector set is configured to receive reflected light energy that is on a given coincident axis unique for that emitter/detector set and process time of flight information for that received light energy." EX1005, 2:66-3:5. Retterath does not specify what types of emitters and detectors are used in its system. *See generally id*. Instead, Retterath describes the emitters and detectors generally, disclosing that "[e]ach emitter of emitter elements 100 of emitter/detector array 10 can comprise vertically-constructed laser diodes that can be configured to project beams of light at known angles relative to a vector of the device normal to a plane of the array 10" and that "[e]ach detector of detector elements **200** can be configured as a photoreceptor such as a photodiode or phototransistor which converts light into an electrical signal." *Id*., 6:57-59.

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72. Figure 4 of Retterath shows an array of emitters **100** that each emit a beam **110** with vector **120**:

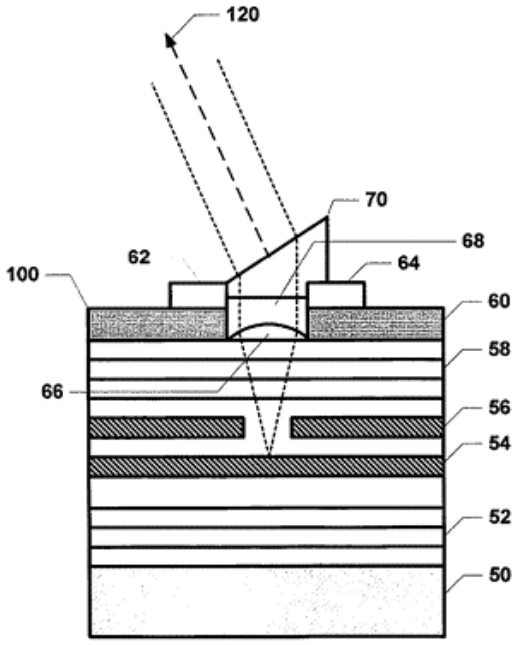
Figure 4



Id., FIG. 4.

73. Figure 5a of Retterath shows "a cross section of a side view of an emitter of emitter elements 100" where "[a] directional lens 70 directs the collimated beam of light 68 along a desired emitter vector 120." *Id*., 8:20-50.

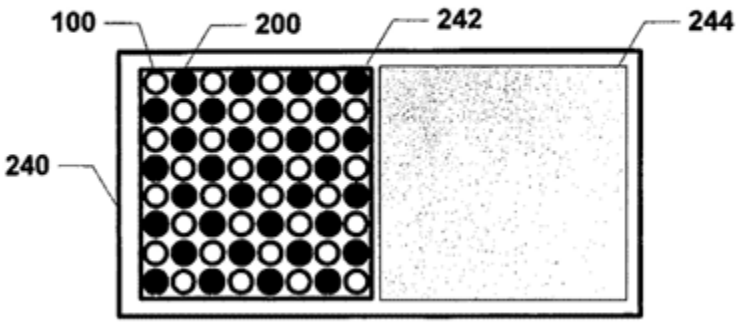
Figure 5a



Id., FIG. 5a.

74. Retterath further discloses that a "single global lens can be used for emitter elements 100 and detector elements 200. *Id*., 10:50-51, 11:10-15 ("global lens detectors").

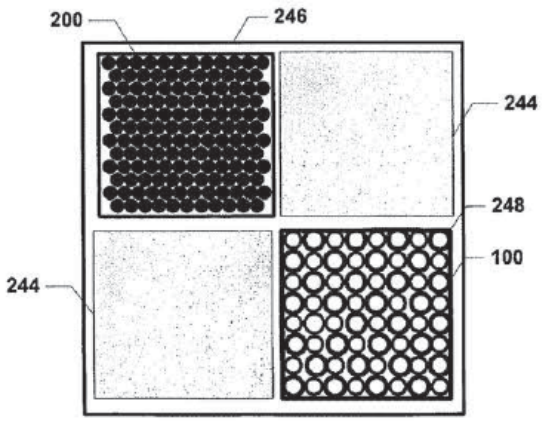
Figure 11a



Id., FIG. 11a.

75. Figure 11b of Retterath shows "emitter elements 100 [that] can be arranged in an emitter electro-optical section 248 and detector elements 200 [that] can be arranged in a detector electro-optical section 246 of device 240." *Id*., 10:61-66. While "[t]he number of detector elements 200 can be equal to or greater than the number of emitter elements 100[,]" Figure 11b shows different arrangements of the detector elements 200 (as a staggered grid) and the emitter elements 100 (as an even grid). *Id*., 10:66-11:4.

Figure 11b



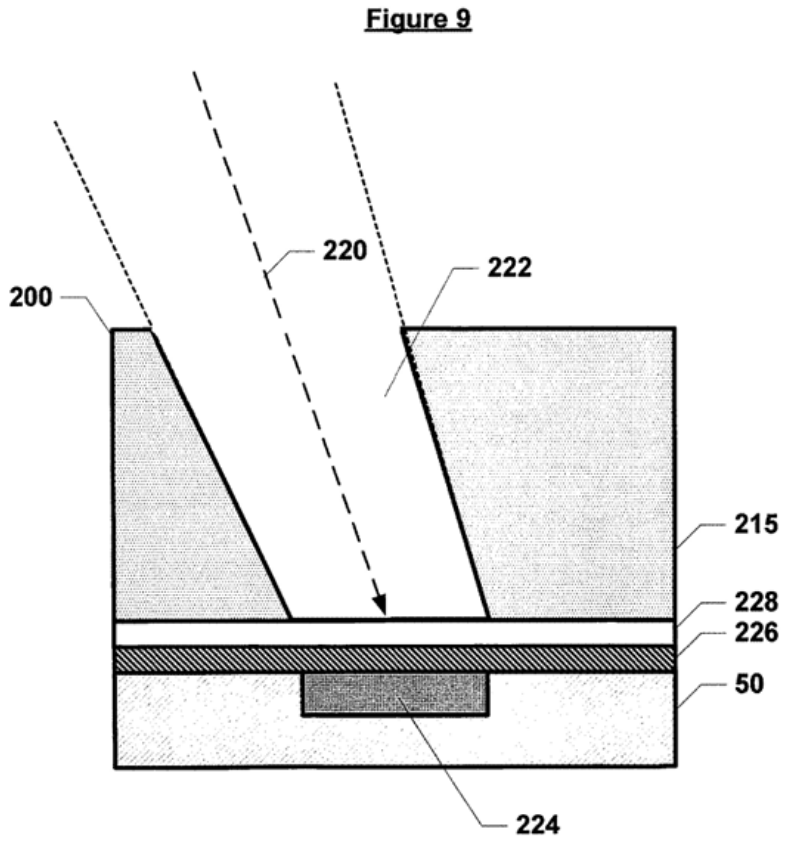
76.

Id., FIG. 11b.

77. Figure 9 of Retterath shows "a cross section of a side view of a detector of detector elements **200** element fabricated with an angular waveguide." *Id*., 10:4-6. "The waveguide wall . . . consist[s] of a material that is substantially non-reflective for the wavelength or range of wavelengths of the emitted light." *Id*., 10:14-17. Retterath discloses that waveguide material **215** "partially reduces[s] in

intensity" or "substantially" blocks light. *Id*., 10:14-17, 9:56-65 ("Each detector of detector elements 200 has an optimal receive detector vector (coincident axis) 220 along which the maximum optical energy will be transferred. Inbound optical energy that is slightly non-parallel to the detector vector 220 will be partially reduced in intensity due to waveguide blocking or due to the macro lens. Inbound optical energy that is more than slightly-non-parallel to the receive detector vector (coincident axis) 220 will be substantially blocked by the detector waveguide or directed elsewhere by the macro lens."), *see also* EX2010, 76:1-18 ("if it's an opaque material, it shouldn't [allow light in], and if you choose your material right, it shouldn't [allow light in].").

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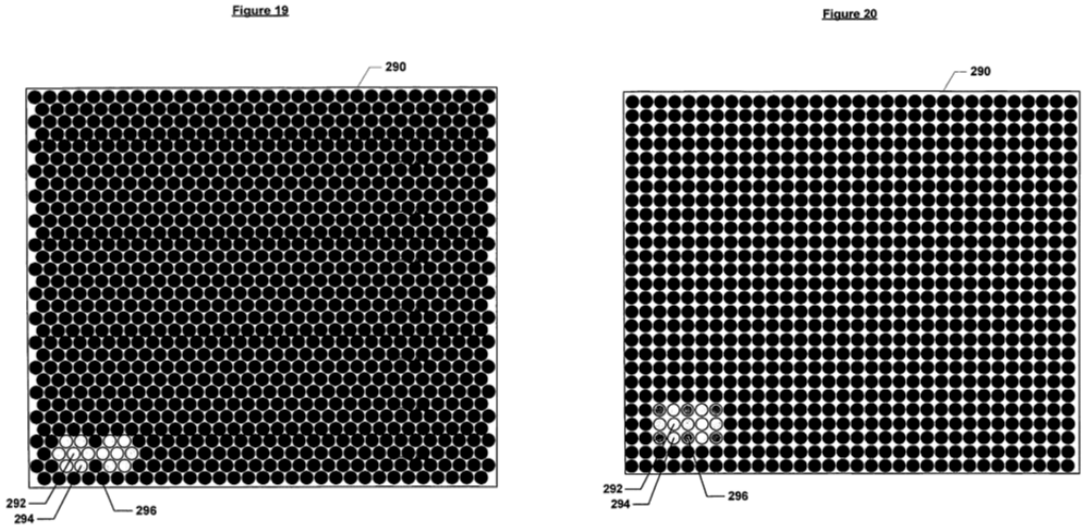


Id., FIG. 9.

78. Retterath also discloses that "[f]or each emitter/detector set of elements 100/200, the emitter and detector vectors are coincident and form a common on-coincident axis that is at an angle relative to a vector normal to the plane of the array that is unique for that emitter/detector set." *Id*., 6:23-39. According to Retterath, a light beam that has "a smaller round spot 94 size" is advantageous, since it "will generally reduce or remove crosstalk with detectors that are near the on-coincident axis matched detector for" an emitter. *Id*., 9:36-44. Retterath further notes that "[s]ince the vectors are similar, emitted energy from one emitter will possibly be

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received at a detector that is not its pair." *Id*., 11:33-37. Because of this, Retterath discloses embodiments with "a plurality of detector elements for each emitter element." *Id.*, 17:43-46, FIGS. 19-20, 17:58-60 ("secondary detectors"), 18:29-32 ("tertiary detectors").



Id., FIGS. 19 and 20.

B. Borowski

79. U.S. Patent Application Publication No. US 2013/0300838 A1 ("Borowski") discloses a 3D landscape real-time imager using "an ultra-short laser pulse source" and a set of SPAD detector arrays. EX1006, Abstract, [0001] ("The present invention relates generally to methods and devices for generating a representation of at least one object in a 3D scene in the real word.").

80. Borowski discloses that its device "provide[s] an imaging technique capable of generating a precise image of complex scenes in a faster way than with

conventional imaging techniques" and that its device "offers an improved trade-off between image depth resolution and fast data acquisition for the detection of movements." *Id*., [0003]. Borowski further discloses that "the recovery time of [ ] SPADs" limits the acquisition speed of the devices as a whole and proposes using "multiple SPADs" to solve this problem. *Id*., [0044].

81. Figure 1 of Borowski shows "four SPAD sensor cells 3-6 built on the same first CMOS IC 1." *Id*., [0154].

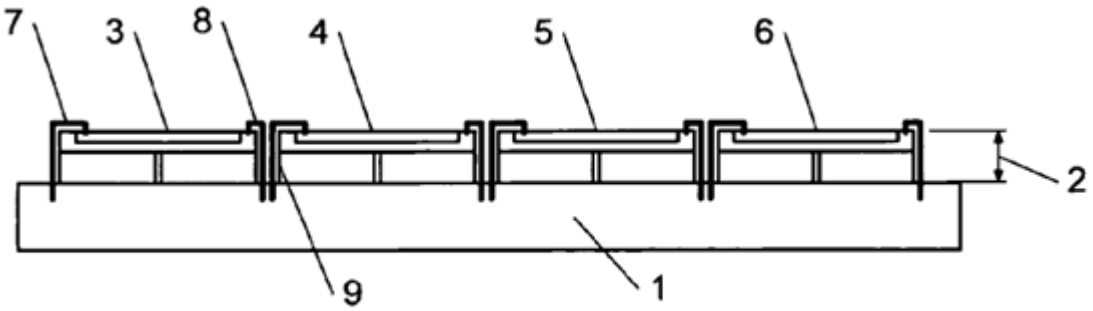


Fig. 1

Id., FIG. 1.

82. Figure 12(a) of Borowski shows "a 4-SPAD sensor cell 92 of the SPAD sensor array" and Figure 12(b) shows the same 4-SPAD sensor cell 92 receiving 3 pulses. *Id*., [0233]-[0234], FIG. 12.

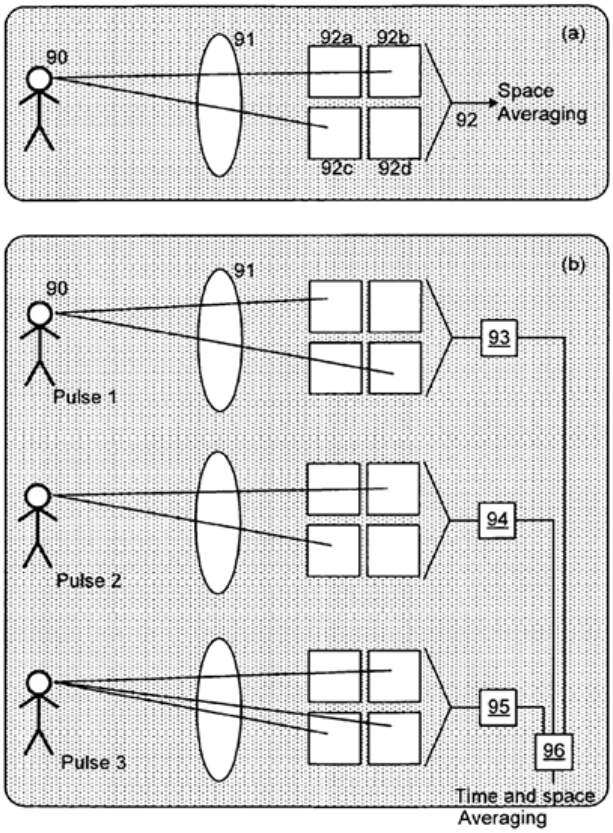
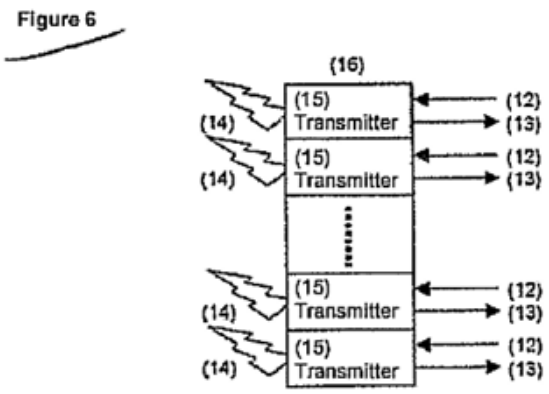


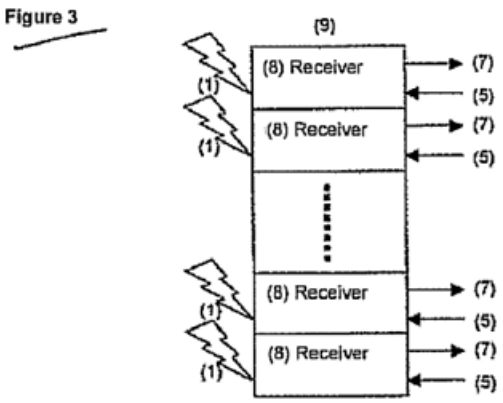
Fig. 12

Id., FIG. 12.

C. Hipp

83. U.S. Patent No. 7,787,105 ("Hipp") is a patent that discloses "[a] system and method for the taking of a large number of distance images having distance picture elements." EX1007, Abstract. Hipp takes these distances images by using a laser scanning device including an array of transmitters 15 and an array of receivers 8. *Id*., 1:27-37, FIGS. 3, 6, 11:63-12:4, 12:16-29.

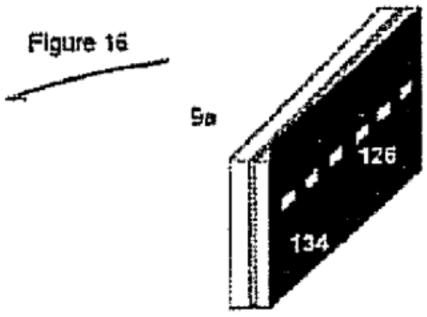




Id., FIGS. 3 and 6.

84. Hipp discloses different configurations of the receivers 8 and transmitters 15, including a configuration where there is "precisely one laser per APD." *Id*., 21:23-28. Hipp does not specify how the lasers and APD are arranged with respect to one another.

85. Hipp also describes a "basic problem of the array technique[,]" which is that "electrical interference pulses arise which superimpose themselves with the desired signals." *Id*., 21:46-56. To solve this problem, Hipp teaches using a reflective "mirror coated" shadow mask that is "printed onto the cover plate of the APD array or onto an APD with impermeable material." *Id*., 21:57-67. The shadow mask 134 is shown in Figure 16 below:



Id., FIG. 16.

D. Weimer

86. U.S. Patent No. 8,736,818 ("Weimer") is a patent that discloses "electronically steered flash LIDAR systems and methods in which illumination within a scene is adaptively controlled[.]" EX1008, 1:5-9.

87. Figure 3A shows a flash LIDAR system for use in a spacecraft 108 in which a light source 304 (e.g., a laser) is input into a steering device 316 and is sent through transmit optics 318 to bounce off of a target scene 112, and is received through receiver optics 322 by "Flash Detector Array" 324. *Id*., FIG. 3A, 8:48-10:45.

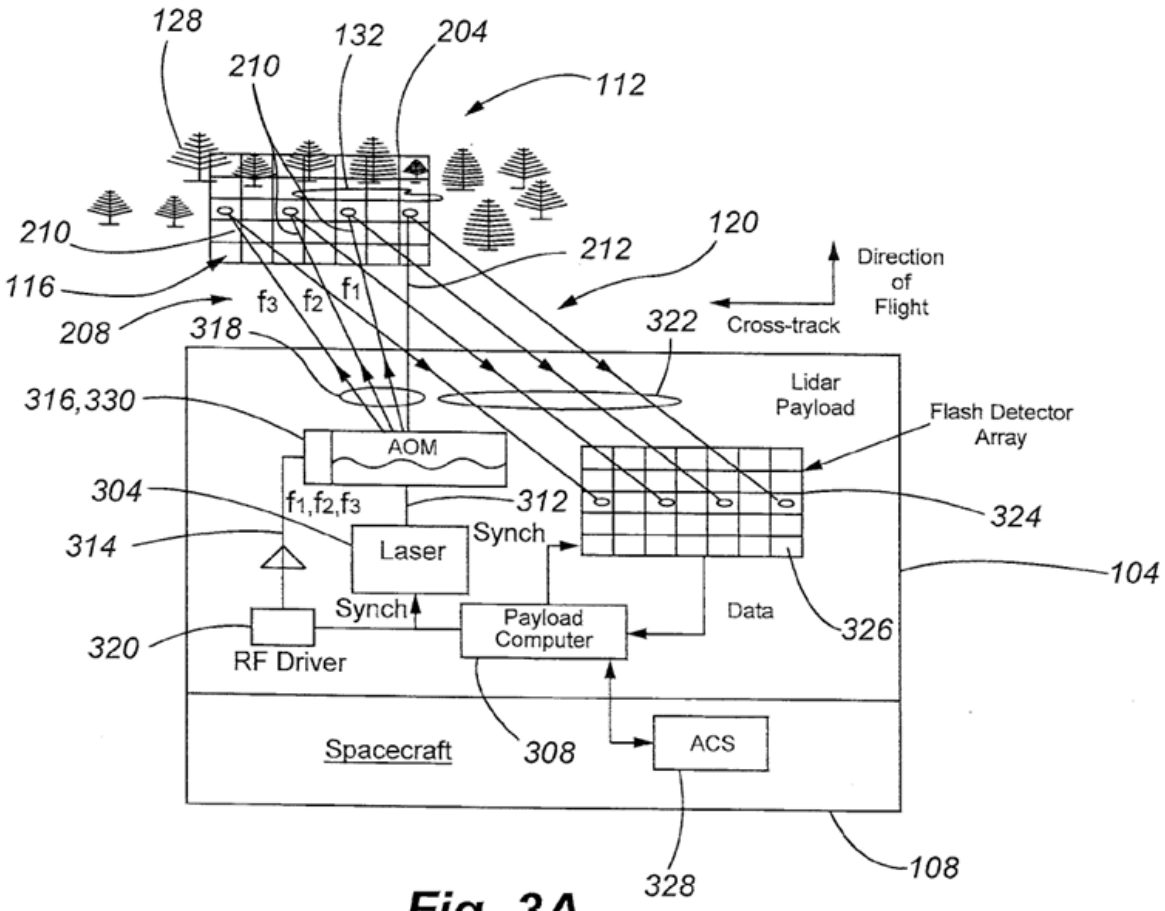


Fig. 3A

Id., FIG. 3A.

88. Weimar describes each of its systems as being used in spacecraft or aircraft applications. *See e.g.*, *id.*, FIGS. 1A-1D, 3A-3F, 1:20-23 ("LIDAR systems have been proposed for use in connection with various applications. For example, NASA and the scientific community have been working towards a space mission to characterize vegetation, specifically vegetation canopy . . .. Other applications in space include rendezvous and docking, robotic rovers, planetary mapping, terrain relative navigation for future landers, and long range target position and range

tracking."), 4:2-6 ("In this example, the platform 108 is an airplane, however, other platforms 108 may be associated with the LIDAR system 104. Examples of other platforms include satellites, helicopters, unmanned aerial vehicles, autonomous rovers, balloons, stationary supports, or spacecraft.").

89. In the context of space and aircraft applications, Weimer teaches a relatively high "laser repetition rate of approximately 250 Hz" when carried by a satellite and notes that this repetition rate has "a significant impact on laser reliability" and also notes that "such a system may have insufficient power to make measurements through clouds and heavy aerosol layers." *Id*., 1:24-35. Weimer also discloses that large fields of view are not desirable due to an increase in background light. *Id*., 1:53-56. To solve this problem, Weimer discloses making the laser spot size smaller than the receivers' field of view. *Id*., 1:56-59.

E. Imai

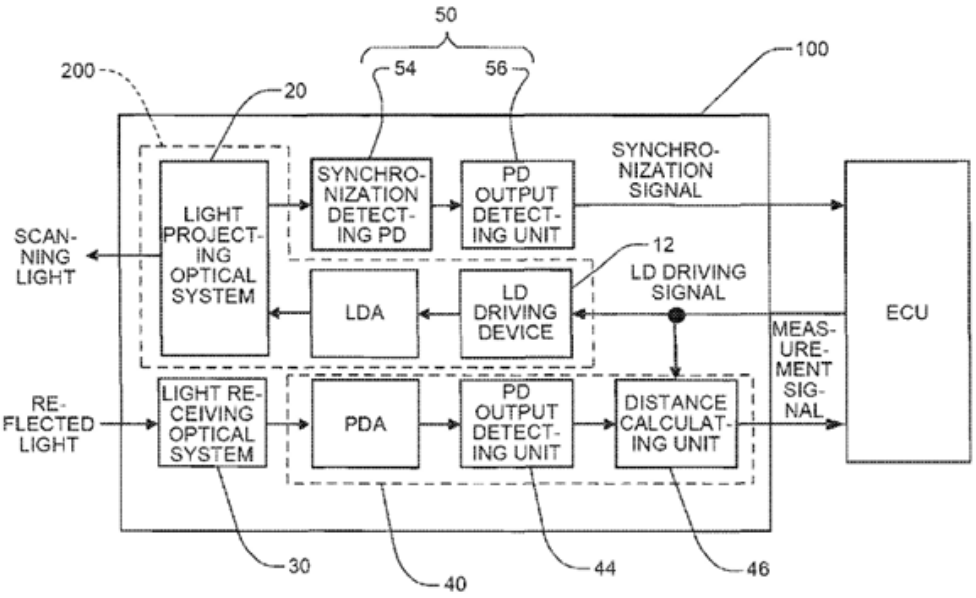
90. U.S. Patent Application Publication No. 2016/0274223 A1 ("Imai") discloses an "object detecting device." Ex. 1009, [0008]. I understand that Dr. Shanley is relying on Japanese Application No. JP2015-055314 in support of the alleged priority of Imai over the '750 patent. I also understand that unless Imai can claim support from Japanese Application No. JP2015-055314, Imai is not prior art to the '750 patent.

91. Imai's "object detecting device includes: a light source which includes

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a plurality of light emitting units arranged in a sub-scanning direction; a deflector which deflects light from the light source; and an optical detector which includes a plurality of light receiving units arranged in the sub-scanning direction so as to correspond to the plurality of light emitting units, and receives light deflected by the deflector and reflected by an object." *Id.*, [0008]. Figure 1 of Imai, which is reproduced below, shows "a schematic configuration of a laser radar." *Id.*, [0010], FIG. 1.

FIG.1



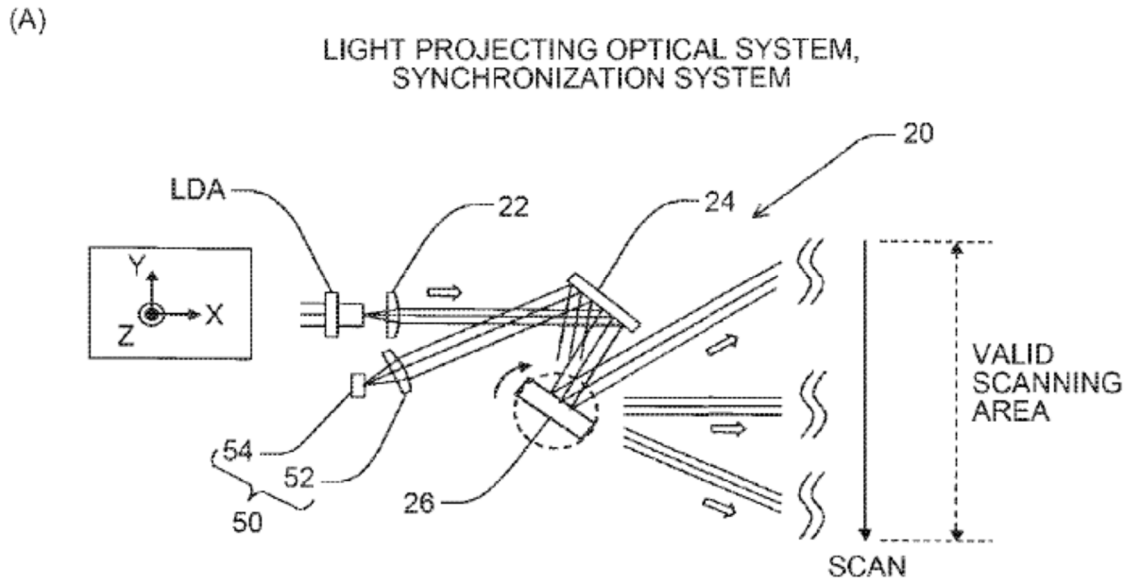
Id., FIG. 1.

92. Imai discloses that "[t]he laser radar 100 [shown in FIG. 1 above] is a scanning laser radar mounted on an automobile as a mobile object for detecting whether there is an object (for example, a preceding vehicle, a stopping vehicle, an

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obstacle, a pedestrian and the like) by emitting light and detecting a distance to the object and the like by receiving reflected light (scattered light) from the object, as an example." *Id*., [0027]. "The laser radar 100 is provided with an LDA (laser diode array) including a plurality of LDs (laser diodes) as a light source, an LD driving device 12, a light projecting optical system 20, a light receiving optical system 30, a detection system 40, a synchronization system 50 and the like as illustrated in FIG. 1." *Id*., [0029].

93. Figure 2(A) of Imai shows a "light *projecting* optical system 20 and the synchronization system 50." *Id*., [0031].

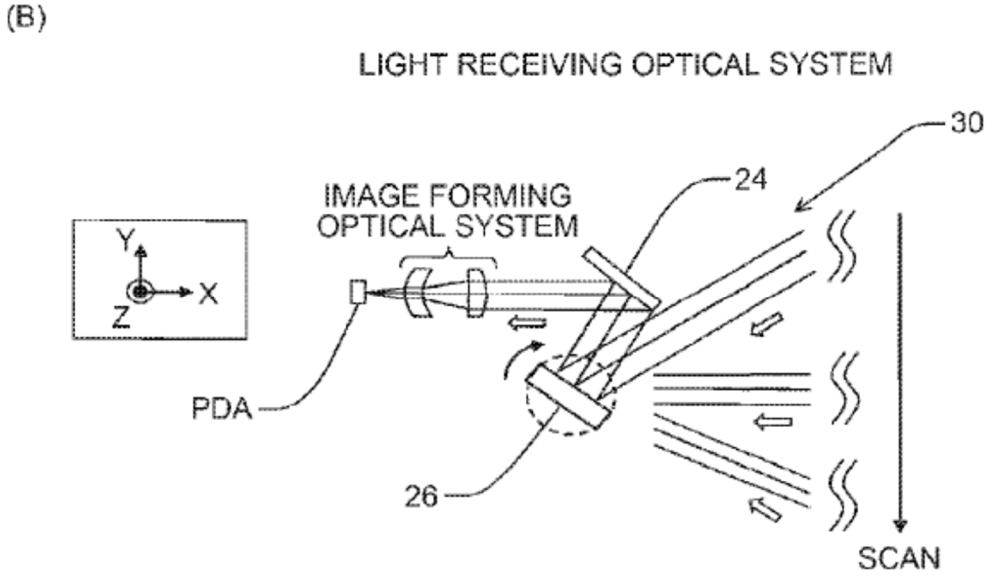


Id., FIG. 2(A).

94. As shown above, the "light projecting optical system 20 includes a coupling lens 22 arranged on an optical path of the light from the LDA, a reflecting

mirror 24 arranged on the optical path of the light through the coupling lens 22, and a rotary mirror 26 as a deflector arranged on the optical path of the light reflected by the reflecting mirror 24." *Id*., [0032].

95. Figure 2(b) of Imai shows a "light *receiving* optical system 30." *Id*., [0031].

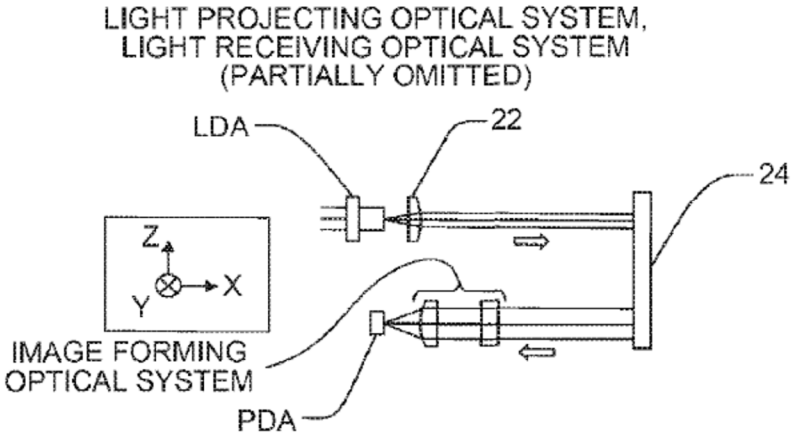


Id., FIG. 2(B).

96. "The light receiving optical system 30 includes the rotary mirror 26 which reflects the light projected from the light projecting optical system 20 to be reflected (scattered) by the object located in the valid scanning area, the reflecting mirror 24 which reflects the light from the rotary mirror 26, and an image forming optical system arranged on the optical path of the light from the reflecting mirror 24 to form an image of the light on a PDA (photo diode array) as an optical detector." *Id*., [0037].

97. Figure 2(C) of Imai shows "the optical path from the LDA to the reflecting mirror 24 and the optical path from the reflecting mirror 24 to the PDA are illustrated in a partially omitted manner." *Id*., [0038], FIG. 2(C).

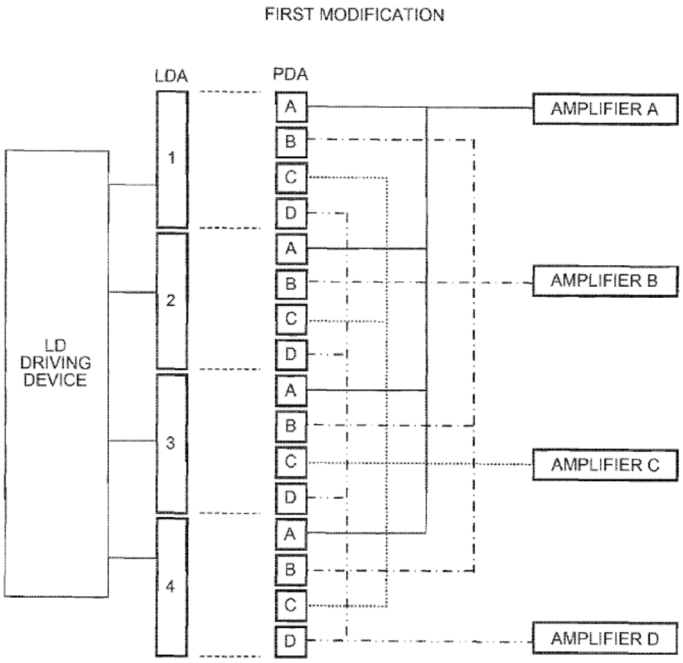
(C)



Id., FIG. 2(C).

98. Figure 10 of Imai discloses PDAs and LDAs where the PDA is "a vertically stacked photo diode array in which a plurality of (for example, 16) PDs of PD1 to PD16 is stacked in the Z-axis direction (vertical direction)" and the LDA is "a vertically stacked laser array in which a plurality of (for example, four) LDs of LD1 to LD4 is stacked in a Z-axis direction (vertical direction)." *Id*., [0097]-[0098], FIG. 10. Imai discloses that, in the configuration shown in Figure 10, "[t]he irradiation range of each LD is set to be slightly larger than corresponding light receiving ranges of the four PDs." *Id*., [0101].

FIG.10

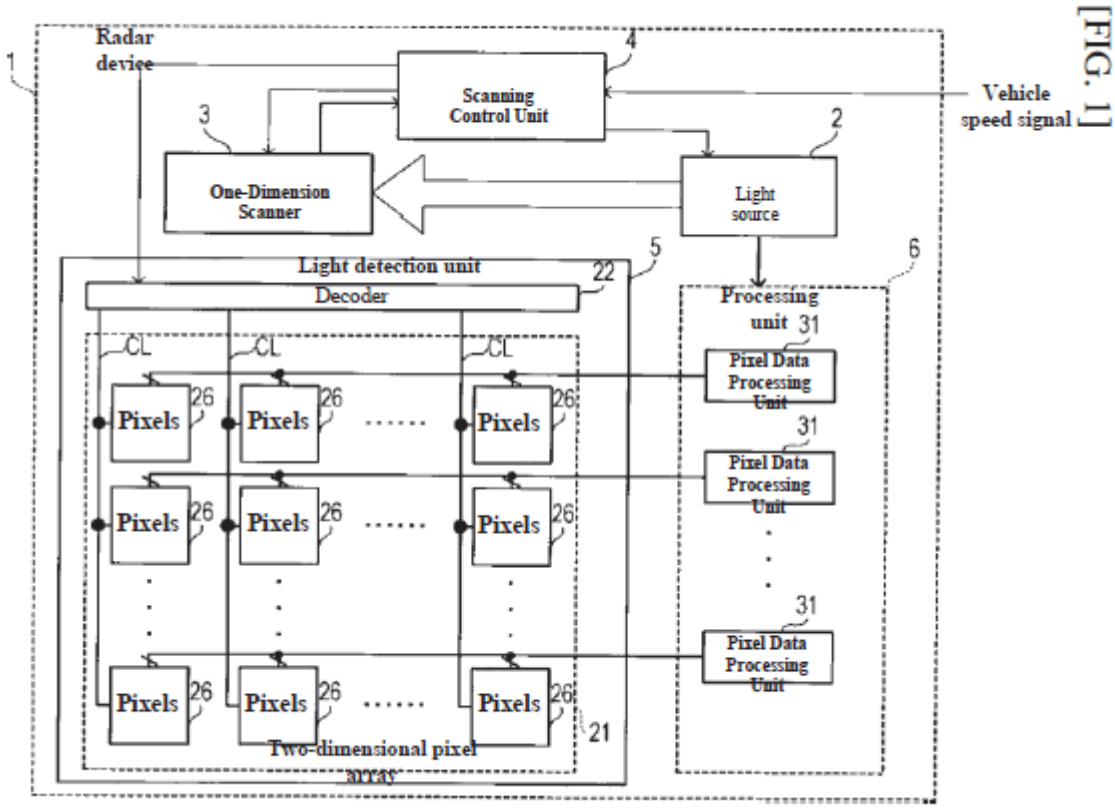


Id., FIG. 10.

F. Higashi

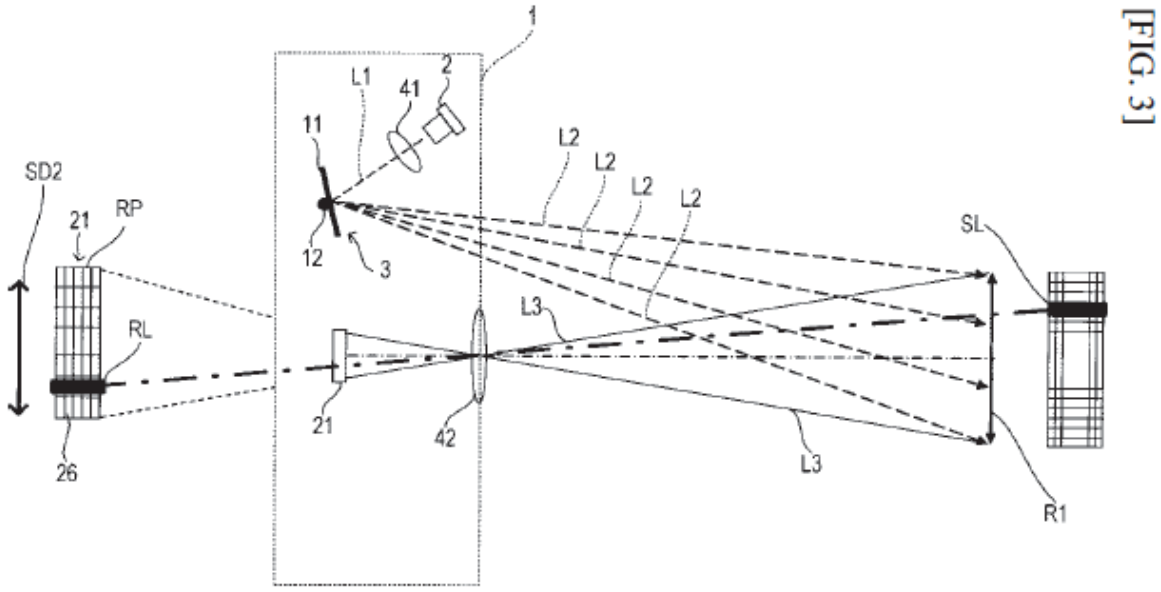
99. Japanese Publication No. 2015-078953 ("Higashi") is a publication that discloses "[a] radar device 1 [that] is mounted in a vehicle and [that] comprises of a light source 2, a one-dimensional scanner 3, a scanning control unit 4, a light detection unit 5 and a processing unit 6." EX1011, [0015], FIG. 1.

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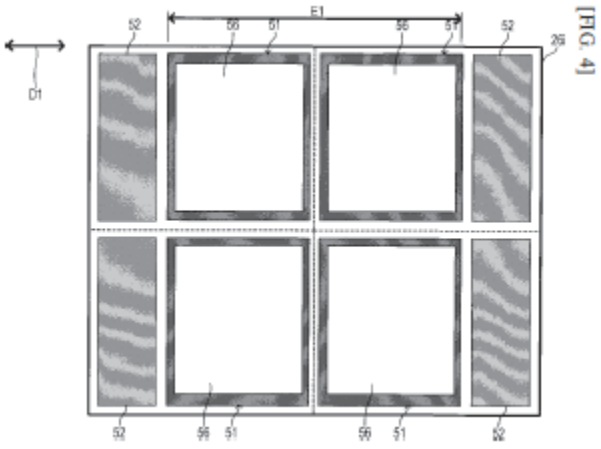
Id., FIG. 1.

100. Higashi further discloses that, in radar device 1, "light source 2 irradiates the laser light towards the one-dimensional scanner 3 via the collimating lens 41." *Id.*, [0024]. The laser light is "reflected by mirror 11, and is irradiated as a radar wave in a direction corresponding to the scanning angle of the mirror 11." *Id.* The laser light then reflects off of "an object located in front of the vehicle" and "reaches the two-dimensional pixel array 21 after passing through the light receiving lens 42." *Id.*, *see also id.*, FIG. 3.



Id., FIG. 3.

101. Figure 4 of Higashi shows "pixel 26 compris[ing] four light receiving elements 51[,]" where each light receiving element is "a single photon avalanche diode (SPAD)." *Id.*, [0027], FIG. 4.



Id., FIG. 4.

G. Grzesik

102. U.S. Patent Application Publication No. US 2017/0040368 A1 ("Grzesik") is a patent application that discloses "photodiodes that can generate light in the manner of avalanche photodiodes such as Geiger-mode avalanche photodiodes." EX1012, [0002].

103. Figure 3 of Grzesik shows "a schematic view of a cross talk absorber layer that can be provided on a photodiode array substrate":

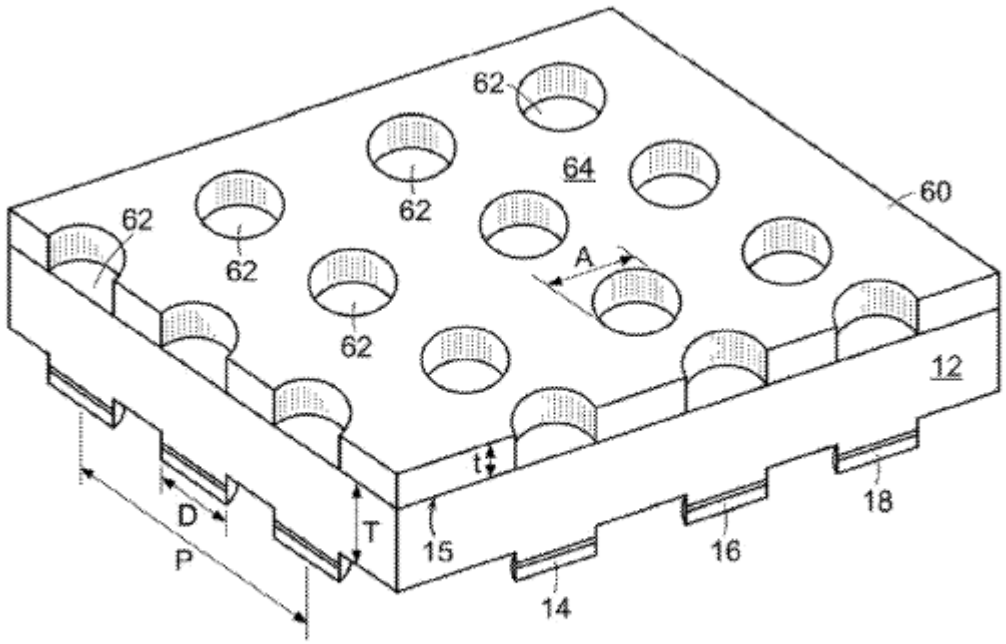


FIG. 3

Id., FIG. 3, [0012].

104. Figure 4 of Grzesik shows "a cross-sectional side view of the photodiode array of FIG. 1 here including the cross talk absorber layer **60**":

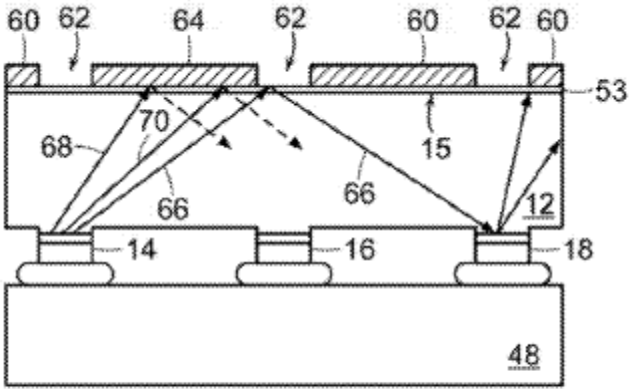


FIG. 4

Id., FIG. 4; [0035]. Grzesik discloses that "blanket-coating material regions **64** of the cross talk absorption layer **60** at least partially suppress, at the optical interface **15**, the internal reflection of secondary radiation that is generated in the substrate due to recombination or relaxation of electrical charge at a photodiode structure during an avalanche event, while the apertures 62 allow transmission of primary external photons into the substrate 12 and to photodiodes in the photodiode array." *Id.*, [0034].

VII. CLAIM CONSTRUCTION

A. "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" (claim 44)

105. Claim 44 of the '750 patent recites the following: "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where **electromagnetic**

radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels." EX1001, claim 44 (emphasis added).

106. It is my opinion that a POSITA would have understood the term "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" in claim 44 of the '750 patent to mean that the electromagnetic radiation output from each emitter in the illumination pattern and the field of view of a corresponding pixel cover substantially the same area in the field.

107. The claim language of the '750 patent supports my understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" term. A POSITA would have understood the "field of view" is a well-established term in the field of optics indicating an area or range of coverage. Accordingly, a POSITA would have understood that for an emitter's radiation output to be coincident with such an area or range, the output would need to cover substantially the same area or range. Claim 16 recites: "The optical imaging system of claim 15 wherein each aperture in the plurality of discrete apertures defines a field of view in the field coincident a discrete spot output by a corresponding laser in the plurality of lasers." EX1001, claim 16. This claim language confirms that the "coincident" term as it arises in the '750 patent

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claim language relates to an *area* or region in the field—*e.g.*, a discrete *spot* output by a laser emitter. *Id.*

108. The '750 patent discloses the system shown in Figure 1 in which each aperture in the set of apertures **144** "defin[es] a field of view in the field coincident a discrete spot output by a corresponding illumination source in the set of illumination sources **110**[.]" EX1001, 2:8-11; *see also id.*, 3:56-59, 10:61-64. In other words, the '750 patent discloses that the "discrete spot" or emission region of an illumination source **110** has substantially the same area in the field as an aperture **140**. The '750 patent specification discloses:

> [B]ecause a second aperture 142 in the aperture layer 140 is offset from the first aperture **142** in the aperture layer **140** is offset from the first aperture **141** and because the **particular region of the surface in the field illuminated via the first illumination source 111 does not (substantially) coincide with the field of view of the second aperture 142**, photons reflected by the particular region of the surface and reaching the bulk imaging optic **130** are projected into the second aperture **142** and passed to a second lens **142** behind the second aperture **142**, and vice versa[.]

EX1001, 5:50-58 (emphasis added). This language confirms that "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" in the '750 patent refers to the radiation output of a particular emitter and the field of view of a corresponding detector

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covering substantially the same area in the field.

109. Figure 1 of the ’750 patent demonstrates, showing light from two illumination sources **110** deflecting off of different areas in the field and entering into different apertures **140**:

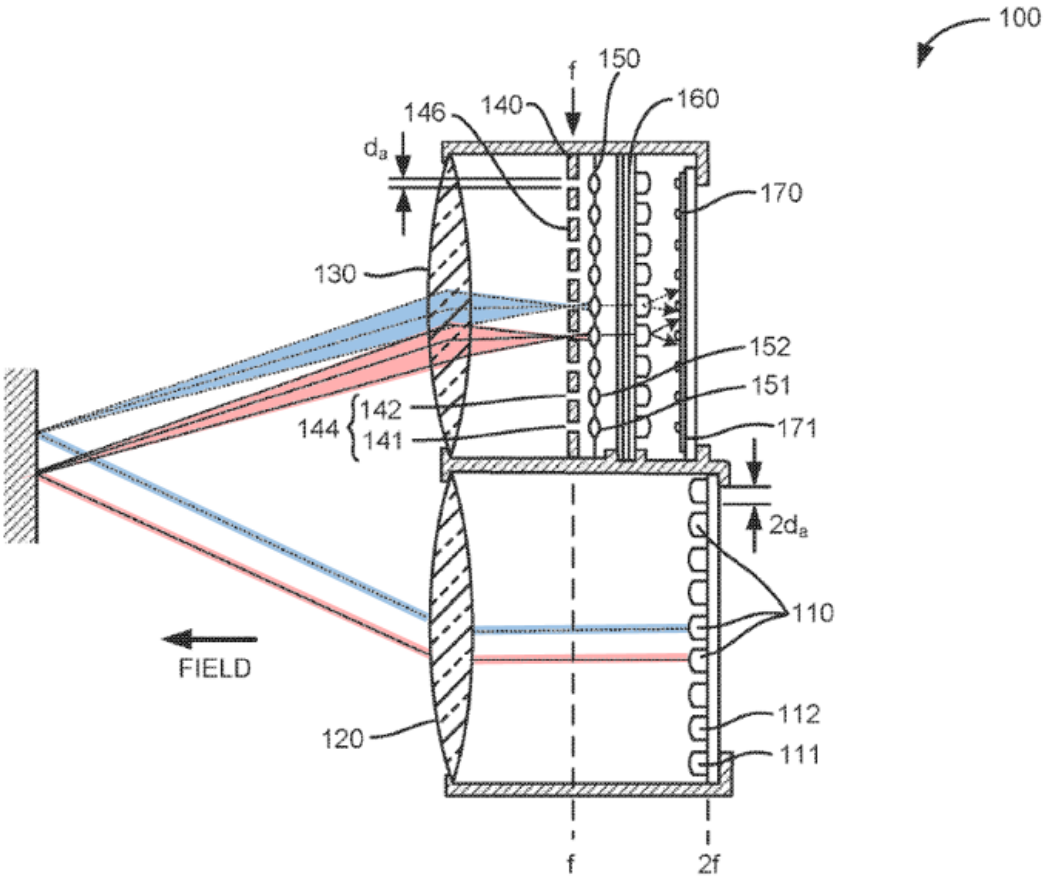


FIG. 1

EX1001, FIG. 1 (colored annotations added). The ’750 patent indicates that each emitter’s radiation output “substantially” matches the field of view of its corresponding detector. EX1001, 2:58-62 (“The system can therefore selectively project illuminating beams into a field ahead of the system according to an

illumination pattern that substantially matches—in size and geometry across a range of distances from the system—the fields of view of the apertures."), 6:3-11.

110. The '750 patent further discloses that it is important for the radiation output of its system's emitters to be substantially matched with the fields of view of the detectors. For example, the '750 patent discloses that:

> the illumination sources are configured to illuminate substantially only surfaces in the field ahead of the system that can be detected by pixels in the system such that **minimal power output by the system (via the illumination sources) is wasted by illuminating surfaces in the field for which the pixels are blind**. The system can therefore achieve a relatively high ratio of output signal (i.e., illuminating beam power) to input signal (i.e., photons passed to an incident on the pixel array).

EX1001, 2:62-3:3 (emphasis added).

111. Further, due to the substantial matching of radiation output and detector fields of view, the '750 patent discloses that:

> a signal passed into the first lens **151** by the first aperture **141** in the aperture layer **140** can exhibit a **relatively high ratio of light rays originating from the first illumination source 111 to light rays originating from other illumination sources in the system**. Generally, because various illumination sources in the system may output illuminating beams at different frequencies, duty cycles, and/or power levels, etc. at a particular time during operation, light rays passed from the bulk imaging optic **130** into a first pixel **171** in

> the set of pixels **170** but originating from an illumination source other than the first illumination source **111** paired with the first pixel **171** constitute noise at the first pixel **171**. Though the relatively small diameters of apertures in the aperture layer **140** may attenuate a total light signal passed from the bulk imaging optic **130** into the set of lenses **150**, **each aperture in the aperture layer 140 may pass a relatively high proportion of photons originating from its corresponding illumination source than from other illumination sources in the system; that is, due to the geometry of a particular aperture and its corresponding illumination source**, a particular aperture may pass a signal exhibiting a relatively high SNR to its corresponding lens and thus into its corresponding pixel.

EX1001, 6:3-28 (emphasis added). The '750 patent discloses that due to the *geometry* of the emitters and apertures (*i.e.*, the fact that each emitter has radiation output in the illumination pattern that covers substantially the same area in the field as the field of view of a corresponding detector), the system has little cross-talk between channels. *Id.*

112. Dr. Shanley appears to understand the term "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" differently. Dr. Shanley testified that, in his view, "coincident" simply means "overlapping." EX2010, 97:8-10. In other words, it appears that in Dr. Shanley's view, there can be a significant mismatch between the

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radiation output of an emitter and the field of view of a detector, and that would still count as a field of view coincident with an emitter's radiation output. For example, Dr. Shanley opined that in his view, each emitter radiation output shown in Figure 2A of Weimer is coincident with the field of view of a detector, even though each detector's field of view is substantially larger than the radiation output of each emitter. EX1003, ¶279. Figure 2A of Weimer is reproduced below, with each emitter radiation output highlighted in green and the excess detector field of view highlighted in red:

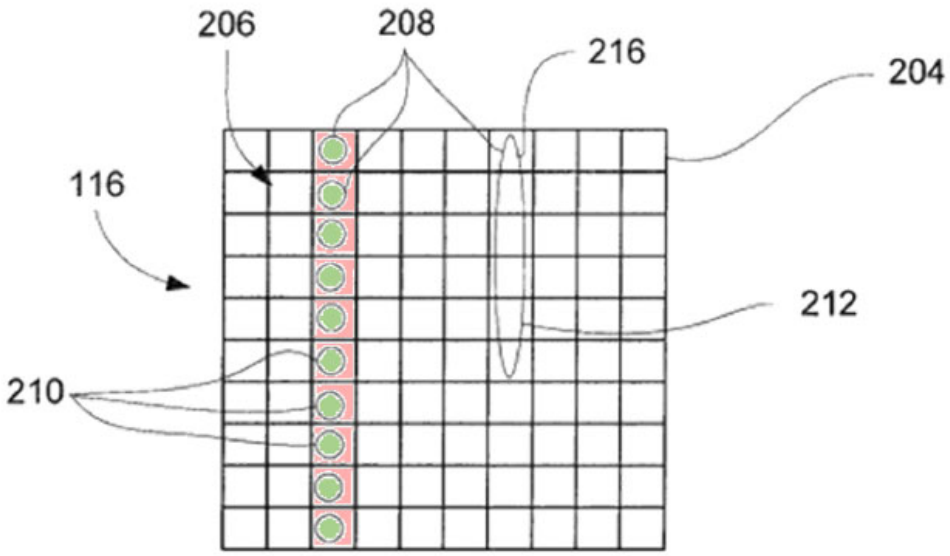


Fig. 2A

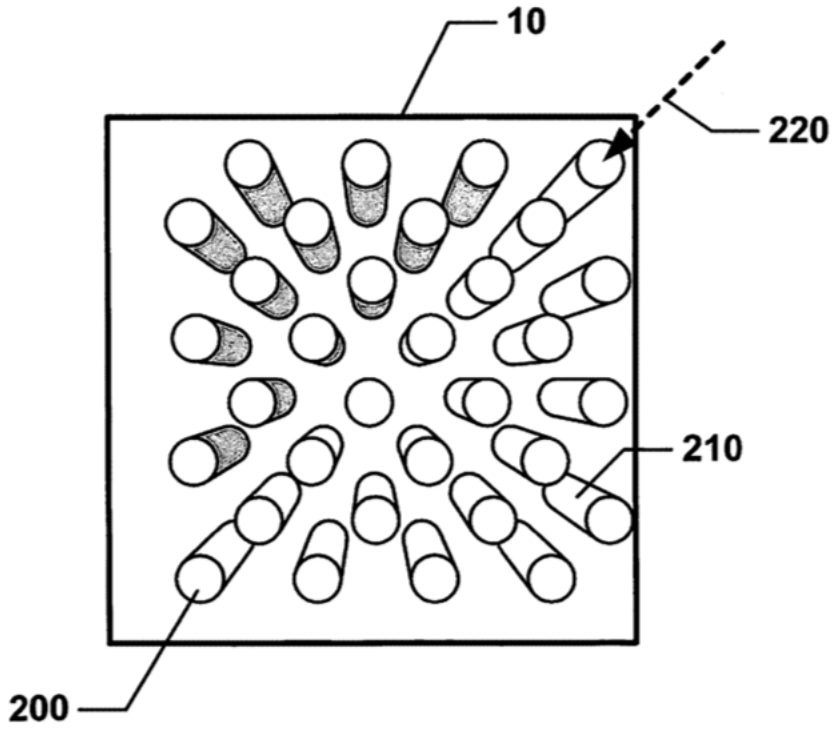
(EX1008, FIG. 2A (highlighting added).)

113. When asked about his understanding of what the limitation "coincident" means in the context of the '381 patent claims (which mirrors the

language of the ’750 patent claims), Dr. Shanley pointed exclusively to the disclosures of the Retterath prior art reference being asserted in this proceeding. EX2010, 32:9-36:14. Dr. Shanley did not point to any other evidence for his understanding of the “coincident” claim term—*e.g.*, he did not point to the ’381 or ’750 patents, any intrinsic evidence related to these patents, or any other resources.

114. Specifically, Dr. Shanley testified that in Retterath, “each emitter has a vector defining a field of view, if you will, which corresponds to the field of view 220, which the vector 220 defines in the detection portion of this circuit. So you have a one-to-one correspondence.” EX2010, 34:1-15; *see also id.*, 33:17-20 (“[E]ach detector element 200 [in Retterath] has an optimal receive coincident axis along which the maximum optical energy will be transferred.”), 35:7-10 (“[E]ach detector of detector elements has an optimal receive detector vector coincident along which the maximum optical energy will be transferred.”). It is the correspondence of these emitter and detector *vectors* that in Dr. Shanley’s view shows that the emitter radiation outputs and detector fields of view are coincident with each other. One of these *vectors* is represented by element **220** in Figure 8 of Retterath, reproduced below. *Id.*, 35:11-13.

Figure 8



EX1005, FIG. 8.

115. Dr. Shanley's testimony indicates that he considers it sufficient for the *direction* of an emitter's radiation output and a field of view of a detector to overlap for that radiation output to be coincident with the field of view. EX2010, 35:14-17 (Q. So element 220 shows the direction of a column of light; is that correct? A. It shows the direction of the light, yes.") However, the direction of light emitted by an emitter or detected by a detector does not reflect the *extent* of the region in the field. *Id.*, 35:18-36:2 ("Q. But the vector doesn't reflect the area of the field of view, does it? . . . A. I think it's pretty clear from the figures of what's happening, and it **defines**

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the direction of the field of view of that particular element as stated in Paragraph 86 [of Dr. Shanley's declaration]." (emphasis added).)

116. I disagree with Dr. Shanley. For the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim limitation to be satisfied, it is not sufficient for the direction, vector, or axis of an emitter's radiation output to match the direction, vector, or axis of the detector. Rather, an emitter's radiation output and a field of view are only coincident when they cover substantially the same *area* in the field. Dr. Shanley's understanding of the term "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" does not account for the area of the emitter radiation output or the detector field of view at all. EX2010, 35:18-36:2. Rather, Dr. Shanley's understanding is based *solely* on the direction of an emitter's radiation output or a detector's field of view—which has no bearing on the *area* of these elements. *Id.*

117. Dr. Shanley's understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim term disregards the language of the '750 patent claims. Claim 44 of the '750 patent recites "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from

each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels." EX1001, claim 44. The claim language makes clear that each *field* of view is coincident with the radiation output of an emitter in the illumination *pattern*. The claim language "*field* of view" and part of an "illumination *pattern*" plainly refers to an *area*—not a direction. Dr. Shanley's understanding of the claim language effectively adds the term "direction" to the claim language per the below—which I understand is improper:

- Dr. Shanley's rewriting of claim 44 of the '750 patent: "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where **the direction of** electromagnetic radiation output from each emitter in the illumination pattern is coincident with **the direction of** a field of view of a corresponding pixel in the plurality of pixels"

118. Further, Dr. Shanley's understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim term does not make sense given the use of the term in the '750 patent's claim language and specification. For example, claim 17 of the '750 patent recites: "an aperture layer disposed between the bulk receiver optic and the array of pixels, the aperture layer including a plurality of discrete apertures of substantially uniform area formed **coincident with the focal plane** and stop regions

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between adjacent apertures." EX1001, claim 17 (emphasis added); *see also id.*, claims 35, 43. Similarly, in discussing Figure 1, the '750 patent discloses "an aperture layer **140** **coincident** the focal plane[.]" EX1001, 2:4-5 (emphasis added); *see also id.*, 4:6-9 ("The aperture layer **140** includes a relatively thin opaque structure coinciding with (e.g., arranged along) the focal plane of the bulk imaging optic **130**, as shown in FIGS. 1 and 2."), 14:16-17. The aperture layer **140** is highlighted in yellow in the annotated version of Figure 1 below:

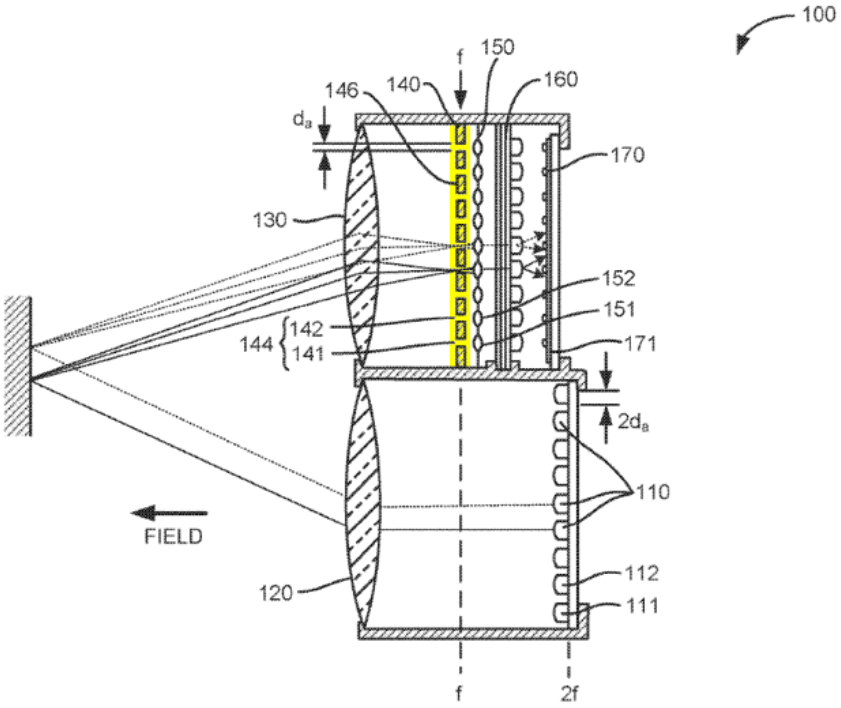


FIG. 1

EX1001, FIG. 1 (colored annotations added). As Figure 1 indicates, the aperture layer is arrayed across the focal plane—indicated by "f" in the figure. Indeed, the aperture layer covers the entirety of the focal plane of bulk imaging optic **130**,

consistent with my understanding that the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim limitations refers to two elements (radiation output and field of view) having substantially the same area. Dr. Shanley's understanding that the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim limitation refers to a correspondence between directional axes simply cannot apply here. For example, aperture layer **140** has no direction, vector, or axis that could correspond to the focal plane. Like an emitter's radiation output or a field of view, the focal plane of the bulk imaging optic in Figure 1 covers an area—not a point. Accordingly, for the aperture layer **140** to be coincident with the focal plane, it must substantially cover the same area as the focal plane.

119. My understanding of the limitation "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" is further supported by the extrinsic evidence. For example, the Oxford English Dictionary (1989) defines "coincident" as "[o]ccupying the same place or portion of space." EX2011 at 5. Further, that dictionary provides optics-related examples consistent with that definition, including examples related to mirrors and reflection. *Id.* Consistent with this definition, my understanding of "electromagnetic radiation output from each emitter in the illumination pattern is

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coincident with a field of view of a corresponding pixel" is that it means an emitter's radiation output and a field of view of a corresponding detector occupy substantially the same "portion of space" in the field. Dr. Shanley's apparent understanding of "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" is inconsistent with the Oxford English Dictionary definition. Dr. Shanley's apparent understanding of the claim limitation is that an emitter's radiation output and a detector's field of view occupy an *overlapping* portion of space, or have the same *direction*. These interpretations are not supported by the Oxford English Dictionary definition of "coincident."

VIII. DR. SHANLEY'S GROUNDS

120. Dr. Shanley opines that the challenged claims of the '750 patent are obvious based on six grounds: (1) claims 44, 45, 48, and 50 over Retterath and Borowski (Ground 1A); (2) claims 44-48 and 50 over Retterath, Borowski, and Weimer (Ground 1B); (3) claims 44, 45, 48, and 50 over Retterath, Borowski, and Hipp (Ground 1C); (4) claims 44-48 and 50 over Retterath, Borowski, Weimer, and Hipp (Ground 1D); (5) claims 44-48 and 50 over Imai, Higashi, and Grzesik (Ground 2); and (6) claims 44-48 and 50 over Weimer, Borowski, and Hipp (Ground 3). I disagree with Dr. Shanley that the challenged claims would have been obvious to a POSITA over any of his asserted prior art grounds.

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A. Ground 1A: Claim 44, 45, 48, and 50 over Retterath and Borowski

121. In my opinion, the Retterath and Borowski combination does not satisfy the requirements of claim 44(c), 44(d), 44(e), or 44(f). Accordingly, it is my opinion that neither claim 44 nor claims 45, 48, and 50 that depend from claim 44 are obvious in light of the Retterath-Borowski combination.

1. Claim 44

(a) The Retterath-Borowski combination does not satisfy "a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels" (claim 44(c))

122. Claim 44(c) of the '750 patent requires "a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel[.]"

123. For the requirement that the field of view of each pixel is "non-overlapping beyond a threshold distance in a field external to the optical imaging system" with the fields of view of all other pixels, no threshold distance is disclosed in the Retterath-Borowski combination.

124. Dr. Shanley's declaration asserts without explanation that the "beyond

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a threshold distance" limitation is satisfied based on the disclosures of Retterath. EX1003 ¶¶149, 151. However, when asked in deposition about what the threshold distance in Retterath is, Dr. Shanley testified that Retterath is not "absolutely designed as an absolute number on it." EX2010, 56:6-11. Accordingly, Dr. Shanley testified that he "can't be certain" about what the threshold distance of Retterath is. *Id.* Further, Dr. Shanley testified that he "[doesn't] believe any patent" discloses a threshold distance like claim 44 of the '750 patent requires". *Id.*, 57:14-18.

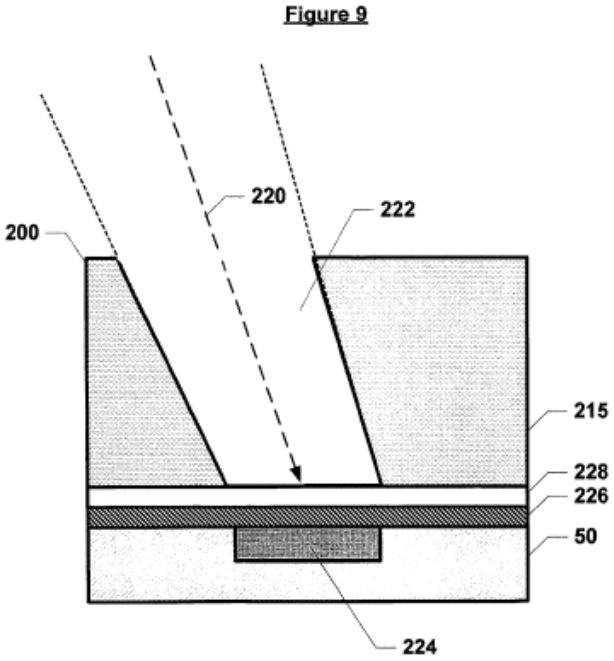
125. It is my opinion that the Retterath-Borowski combination does not satisfy claim 44 of the '750 patent, because there is no "threshold distance" beyond which the fields of view of pixels are non-overlapping.

(b) The Retterath-Borowski combination does not disclose an "aperture layer comprising a plurality of apertures separated from each other by a stop region" (claim 44(d))

126. Claim 44(d) of the '750 patent requires: "an aperture layer disposed between the bulk imaging optic and the plurality of pixels, the aperture layer comprising a plurality of apertures separated from each other by a stop region[.]"

127. For Ground 1A, Dr. Shanley asserts that Retterath satisfies claim 44(d). Dr. Shanley asserts that Retterath's waveguides **222** and waveguide material **215** constitute an aperture layer comprising a thin opaque structure. EX1003 ¶¶155-56. Retterath's Figure 9 shows a waveguide **222** and waveguide material **215** that Dr. Shanley is pointing to in Retterath as the "aperture layer compris[ing] a thin opaque

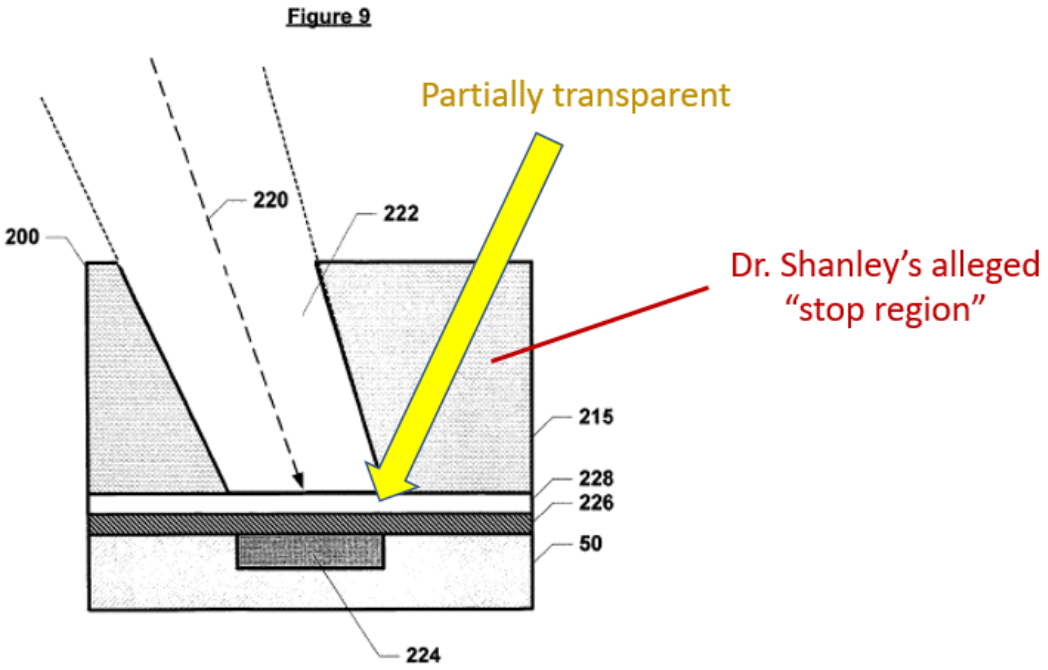
structure":



EX1005, Fig. 9.

128. I disagree with Dr. Shanley that Retterath's waveguides **222** and waveguide material **215** satisfy the requirement of claim 44(d) for an "aperture layer comprising a plurality of apertures separated from each other by a stop region[.]"

129. Retterath's waveguide material **215** is not a "stop region." Rather, Retterath discloses that waveguide material **215** is at least partially transparent to certain light, as shown in the below demonstrative diagram:



EX1005, Fig. 9 (colored annotations added). Retterath repeatedly discloses that waveguide material **215** only "partially reduces[s] in intensity" or "substantially" blocks light. *Id.*, 9:59-65, 10:14-17. Indeed, the only light that Retterath indicates that the waveguide material **215** is configured to absorb is "the wavelength or range of wavelengths of the emitted light." *Id.*, 10:14-17. In other words, Retterath's waveguides are only designed to absorb light emitted by the system itself. Retterath does not provide any indication that the waveguide material **215** absorbs or blocks any other wavelengths of light—*e.g.*, stray light from the environment. Indeed, Retterath's disclosure of "partially" or "substantially" blocking light indicates that there are wavelengths of light that Retterath's waveguide material **215** lets through.

130. Since Retterath's waveguide material **215** is partially transparent to certain light, it is my opinion that Retterath's waveguide material does not constitute

a "stop region" per claim 44(e). The '750 patent specification confirms that "stop region" refers to an opaque or reflecting material—not a partially transparent material. For example, the '750 patent discloses "the aperture layer **140** defines a stop region **146** (i.e., an **opaque or reflecting region**)[.]" EX1001, 4:33-34 (emphasis added). The '750 patent further discloses that "light rays incident on a stop region **146** of the aperture layer **140** are **rejected** (e.g., mirrored or absorbed)[.]" *Id.*, 3:34-36 (emphasis added); *see also id.*, 3:59-62, 5:8-13 ("a stop region . . . blocks light rays . . . from passing"), claim 26 (reciting that a "stop region . . . blocks light rays"). Further, the '750 patent indicates that it is important for stop regions to "block photons," because in blocking light, they "reduc[e] crosstalk" between optical channels. *Id.*, 5:59-63.

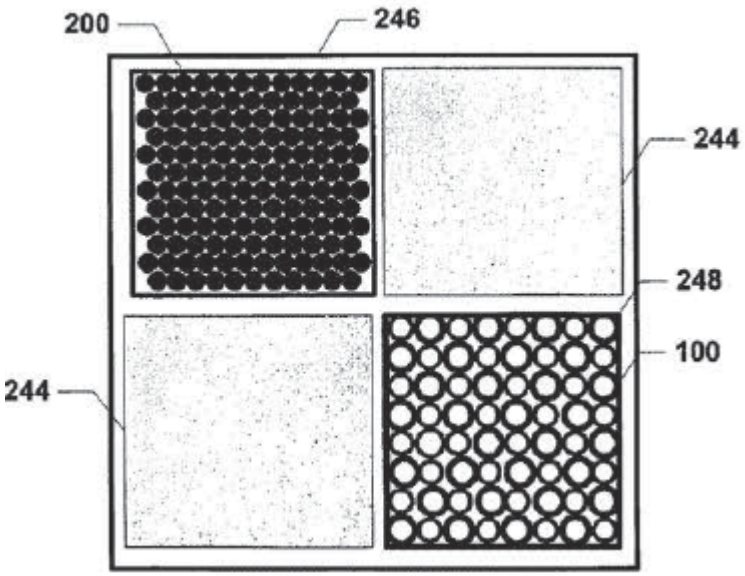
131. Dr. Shanley provides no evidence to support his apparent understanding that a stop region can be a material that "substantially block[s]" light. EX1003, ¶157. In fact, Dr. Shanley testified that *no* light should get through an opaque material like what the '750 patent requires for the "stop region" limitation. When asked in his deposition if waveguide material **215** is still opaque if light can get through that layer, Dr. Shanley testified that "if it's an opaque material, it shouldn't, and if you choose your material right, it shouldn't." EX2010, 76:1-18.

(c) The Retterath-Borowski combination does not satisfy "a bulk transmitting optic disposed adjacent to the bulk imaging optic" (claim 44(e))

132. Claim 44(e) of the '750 patent requires: "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

133. It is my opinion that the Retterath-Borowski combination does not satisfy this limitation. Dr. Shanley relies on the disclosures of Retterath for his opinion that this limitation is satisfied by the Retterath-Borowski combination. EX1003, ¶¶163-67. Specifically, Dr. Shanley relies on Figure 11b.

Figure 11b



EX1005, FIG. 11b. Dr. Shanley asserts that detector elements **200** and emitter elements **100** would each have a bulk optic (*i.e.*, one bulk optic for the detectors and another bulk optic for the emitters), and these bulk optics would be "adjacent to"

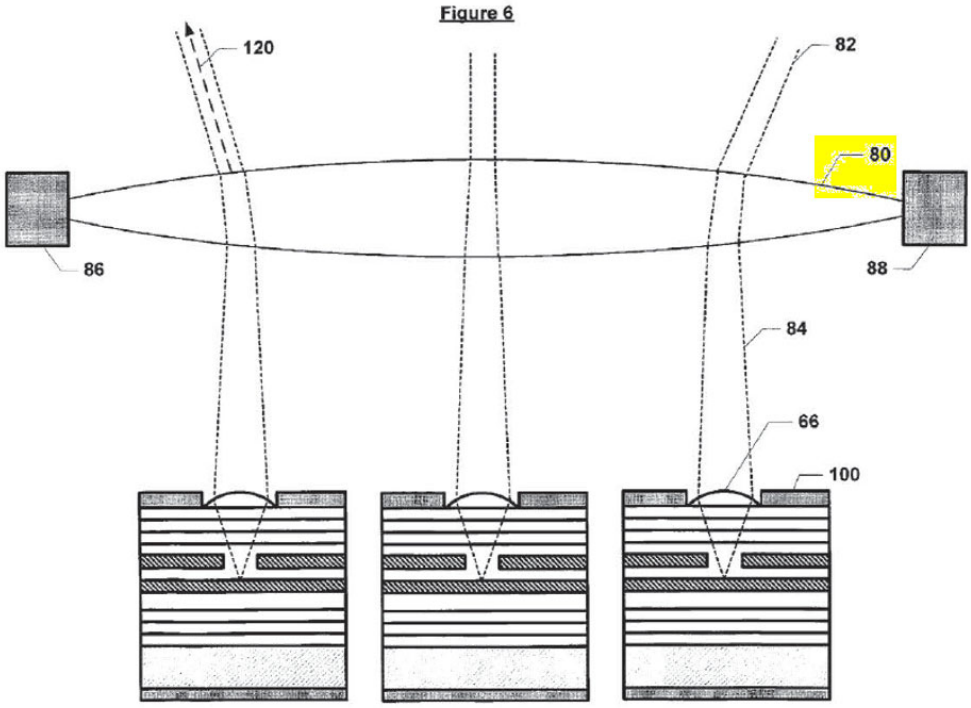
each other based on Dr. Shanley's view of how the optics would be situated relative to the emitter and detector elements. EX1003, ¶166.

134. I disagree with Dr. Shanley's analysis. Retterath indicates that a "**single global lens** can be used for emitter elements **100** and detector elements **200**." EX1005, 10:50-51 (emphasis added), 11:10-15 (discussing "global lens detectors"). Retterath discloses this "single global lens" in connection with Figure 11a, which includes an array where emitters and detectors are included in a single array. *Id.*, 10:50-54. However, Retterath also indicates that this "single global lens" arrangement can be used where there are "[l]arger distances between micro-lens emitter elements and waveguide detector elements" by using "slightly larger diverging waveguides according to FIG. 9." *Id.*, 10:58-60. A POSITA would have understood based on these disclosures that a "single global lens" could be used in the context of the Figure 11b embodiment. Given the interrelated nature of Figures 11a and 11b and their supporting disclosures in Retterath, and, given the lack of discussion about optics in the Figure 11b embodiment otherwise, a POSITA would have understood that Retterath taught the use of a "single global lens" in the context of the Figure 11b embodiment. Accordingly, it is my opinion that the Figure 11b embodiment Dr. Shanley relies on for claim 44(e) does not satisfy the requirement of "a bulk transmitting optic disposed adjacent to the bulk imaging optic"—because a POSITA would have understood that it contains only a *single* "global lens" used

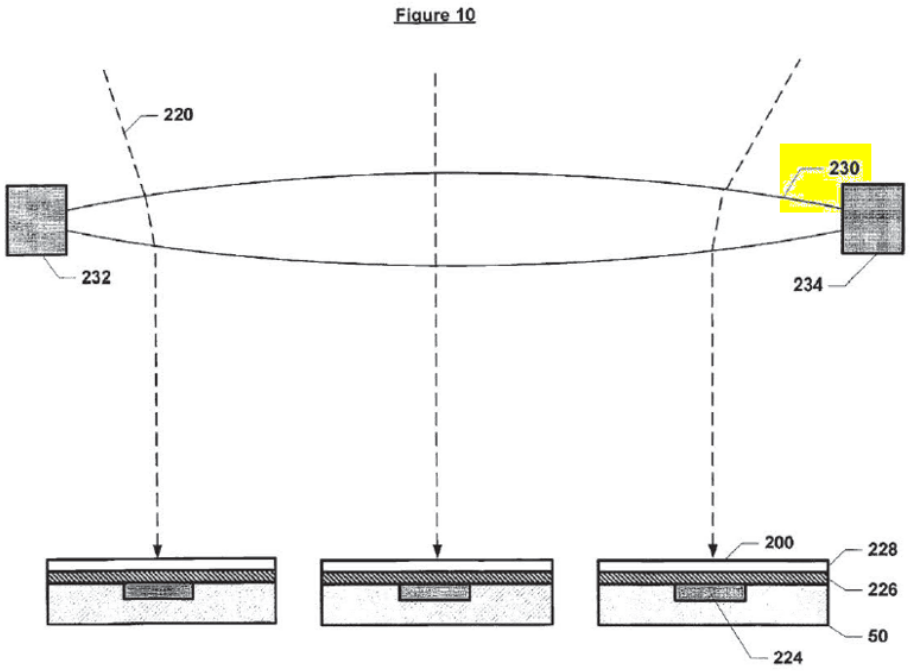
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for both emitters and detectors.

135. To suggest that the requirements of claim 44(e) are satisfied, Dr. Shanley has to look to *other embodiments*. Dr. Shanley takes lens **80** from Retterath's Figure 6 embodiment as a "bulk transmitting optic." EX1003, ¶164.



EX1005, FIG. 6 (highlighting added). Further, Dr. Shanley takes lens **230** from lens **230** from Retterath's Figure 10 embodiment as a "bulk imaging optic." EX1003, ¶165.



EX1005, FIG. 10 (highlighting added).) But Dr. Shanley provides *no* analysis for why a POSITA would have been motivated to import these optics from *other embodiments* into Retterath's Figure 11b embodiment. In other words, Dr. Shanley has provided no indication as to why a POSITA would have been motivated to take *two* lenses from the Figures 6 and 10 embodiments, when a *single* "global lens" is disclosed for the related Figure 11a embodiment.

136. In my opinion, a POSITA would not have been motivated to take a *single* global lens and split it up into *two* lenses. Rather, a POSITA would have been motivated to use fewer elements where possible in order to minimize cost and size requirements and minimize calibration and tuning requirements. Indeed, Dr. Shanley opined in the co-pending IPR2023-1456 proceeding that a POSITA would have been motivated to "provide a more compact and low-cost LiDAR device" for

Retterath's system. EX2018 (-01456 Shanley declaration), ¶223; *see also id.*, ¶¶ 181, 225.

137. Accordingly, it is my opinion that the Retterath-Borowski combination does not satisfy the requirements of claim 44(e).

(d) The Retterath-Borowski combination does not satisfy "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels" (claim 44(f))

138. Claim 44(f) of the '750 patent requires "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels."

139. It is my opinion that the Retterath-Borowski combination does not satisfy claim 44(f) of the '750 patent, because it does not disclose that the electromagnetic radiation output from each emitter is coincident with a field of view of a corresponding pixel in the plurality of pixels, as properly understood.

140. As I discussed above, it is my opinion that a POSITA would have understood the term "electromagnetic radiation output from each emitter in the

illumination pattern is coincident with a field of view of a corresponding pixel" in claim 44(f) to mean that the electromagnetic radiation output from each emitter in the illumination pattern and the field of view of a corresponding pixel cover substantially the same area in the field. *See supra* Section VII.A. I also discuss above that I disagree with Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim limitation, which appears to be that the direction or axis of an emitter matches the direction or axis of a corresponding pixel. *Id.* Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" term only takes account of the *direction* of the emitter radiation outputs and detector fields of view—not the *area*—which in my view is incorrect.

141. Dr. Shanley relies on the disclosures of Retterath for claim 44(f) of the '750 patent. EX1003, ¶¶168-72. Specifically, Dr. Shanley relies on disclosures of Retterath indicating that each pair of emitters and detectors has a "common on-coincident axis that is at an angle relative to a vector normal to the plane of the array that is unique for that emitter/detector set." *Id.*, ¶172 (quoting EX1005, 6:23-39). In other words, Dr. Shanley's opinion appears to be that since each pair of emitters and detectors has a unique shared directional axis, Retterath discloses that

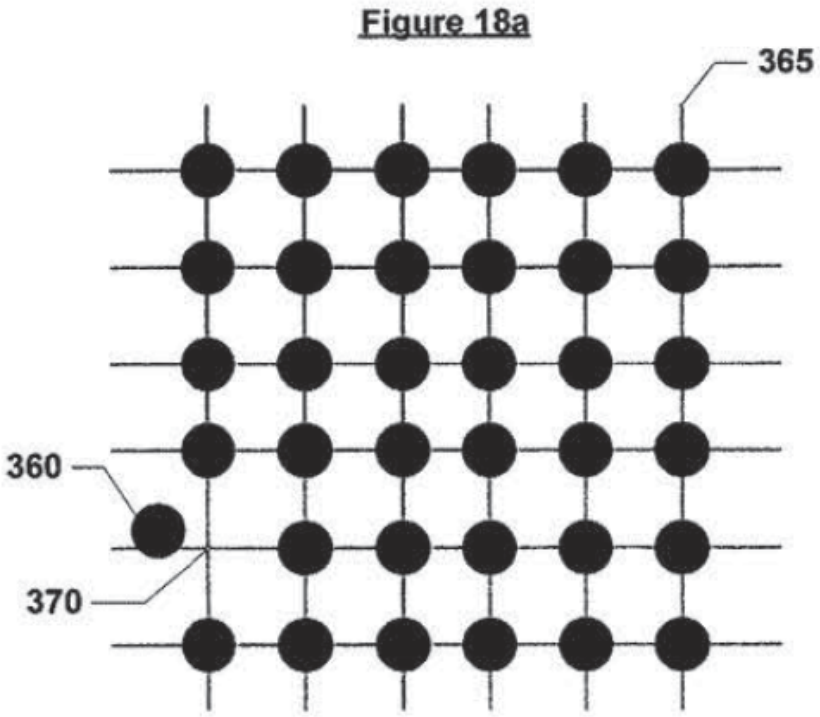
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"electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels." EX1001, claim 44. Dr. Shanley's opinion appears to be based on his understanding (which is incorrect in my opinion) that the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim term merely requires that an emitter matches the direction or axis of a corresponding pixel.

142. In my opinion, Retterath does not disclose that "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels," when the claim limitation is properly understood. In my view, the proper understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim limitation is that the radiation output of an emitter and the field of view of a corresponding pixel cover substantially the same area in the field. Retterath contains no disclosures regarding substantial correspondence between the *area* illuminated by an emitter and the field of view of a detector—as claim 44(f) requires in my opinion. Instead, Retterath discloses that "a **smaller** round spot **94** size" is advantageous, since it "will generally reduce or remove crosstalk with detectors that are near the on-coincident axis matched detector for" an emitter. EX1005, 9:36-44 (emphasis added), FIG. 7. For

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example, Figure 18a of Retterath shows an "ideal location **370** for emitted beams" in its system:



EX1005, FIG. 18a. Because LIDAR uses lasers to generate the emitted beams, a POSITA would have understood that the beams will not spread out or disperse significantly during their travel from the emitter to the destination.

143. Further, Retterath provides numerous examples of the radiation output of an emitter *not* substantially matching the field of view of a corresponding detector. EX1005, 11:33-37 ("Since the vectors are similar, emitted energy from one emitter will possibly be received at a detector that is not its pair."); *see also id.*, FIGS. 19-20, 17:43-46 (disclosing "a plurality of detector elements for each emitter element"), 17:58-60 (disclosing "secondary detectors" around a primary detector for receiving

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light from an emitter), 18:29-32 (disclosing "tertiary detectors").

144. The use of smaller areas of radiation output to reduce cross-talk in Retterath is in line with Retterath's disclosures that cross-talk is a major issue for a system with multiple laser emitters like it discloses. For example, in the "Field of the Invention" section of Retterath, it states that "the present invention relates to non-scanning LiDAR systems using an array of emitter/detector sets to cover a given field of view that provides for **reduced interference due to crosstalk among emitters within a given LiDAR unit** and also among different LiDAR units." EX1005, 1:9-14 (emphasis added). Retterath further discloses that for systems with multiple laser emitters like what it discloses, "[c]are must be taken to ensure that signals received by the photoreceptor are reflected light from the desired emitter source." *Id.*, 5:55-57; *see also id.*, 5:63-67.

145. Accordingly, it is my opinion that the Retterath-Borowski combination does not satisfy the requirements of claim 44(f).

B. Ground 1B: Claims 44-48 and 50 over Retterath, Borowski, and Weimer

146. In my opinion, the Retterath, Borowski, and Weimer combination does not satisfy the requirements of claim 44(c), 44(d), 44(e), or 44(f). Accordingly, it is my opinion that neither claim 44 nor claims 45-48 and 50 that depend from claim 44 are obvious in light of the Retterath-Borowski-Weimer combination.

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1. Claim 44

(a) The Retterath-Borowski-Weimer combination does not satisfy "a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels" (claim 44(c))

147. Claim 44(c) of the '750 patent requires "a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel[.]"

148. For the requirement that the field of view of each pixel is "non-overlapping beyond a threshold distance in a field external to the optical imaging system" with the fields of view of all other pixels, no threshold distance is disclosed in the Retterath-Borowski-Weimer combination. My discussion as to Retterath and Borowski is above. I provide my opinions as to Weimer here.

149. In his report, Dr. Shanley only provides his conclusory opinion that the Retterath, Borowski, and Weimer combination satisfies the "beyond a threshold distance" limitation. EX1003 ¶190. However, in deposition, Dr. Shanley indicated that he could not say what the alleged "threshold distance" is in Retterath, as I discuss above. EX2010, 56:6-11, 57:14-18. Further, Dr. Shanley testified that he

"can't quantify" the threshold distance in Weimer's system. *Id.*, 115:8-11.

150. Accordingly, it is my opinion that the Retterath-Borowski-Weimer combination does not satisfy claim 44 of the '750 patent, because there is no "threshold distance" beyond which the fields of view of pixels are non-overlapping.

(b) The Retterath-Borowski combination does not disclose an "aperture layer comprising a plurality of apertures separated from each other by a stop region" (claim 44(d))

151. Claim 44(d) of the '750 patent requires: "an aperture layer disposed between the bulk imaging optic and the plurality of pixels, the aperture layer comprising a plurality of apertures separated from each other by a stop region[.]"

152. Since Dr. Shanley does not appear to be asserting that the addition of Weimer changes anything about his Ground 1A analysis for claim 44(d) of the '750 patent, it is my opinion that Ground 1B fails to satisfy claim 44(d) for the same reasons I discussed above as to Ground 1A.

(c) The Retterath-Borowski-Weimer combination does not satisfy "a bulk transmitting optic disposed adjacent to the bulk imaging optic" (claim 44(e))

153. Claim 44(e) of the '750 patent requires: "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

154. Since Dr. Shanley does not appear to be asserting that the addition of Weimer changes anything about his Ground 1A analysis for claim 44(e) of the '750

patent, it is my opinion that Ground 1B fails to satisfy claim 44(e) for the same reasons I discussed above as to Ground 1A.

(d) The Retterath-Borowski-Weimer combination does not satisfy "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels" (claim 44(f))

155. Claim 44(f) of the '750 patent requires "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels."

156. It is my opinion that the Retterath-Borowski-Weimer combination does not satisfy claim 44(f) of the '750 patent, because it does not disclose that the electromagnetic radiation output from each emitter is coincident with a field of view of a corresponding pixel in the plurality of pixels, as properly understood.

157. As I discussed above, it is my opinion that a POSITA would have understood the claim limitation "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" in claim 44(f) to mean that the electromagnetic radiation output from each emitter

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in the illumination pattern and the field of view of a corresponding pixel cover substantially the same area in the field. *See supra* Section VII.A. I also discuss above that I disagree with Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim term, which appears to be that the direction or axis of an emitter matches the direction or axis of a corresponding pixel. *Id.* Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" term only takes account of the *direction* of the emitter radiation outputs and detector fields of view—not the *area*—which in my view is incorrect.

158. In my opinion, Retterath does not satisfy the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" requirement of claim 44(f), because it does not disclose that its emitters have radiation outputs that cover the same area in the external field to the fields of view of their corresponding detectors. *See supra* Section VIII.A.1(d). Dr. Shanley asserts that "a POSITA would have been prompted to match the field-of-view of each pixel to the radiation output of an emitter, based on Weimer's suggestions, to improve signal to noise (SNR) in the pixel array in the Retterath-Borowski combination." EX1003, ¶180. However, as I discuss below in connection

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with Dr. Shanley's Ground 3, Weimer *also* does not disclose emitters that have radiation outputs that cover the same area in the external field to the fields of view of their corresponding detectors. *See infra* Section VIII.F.1(d). Accordingly, in my opinion, the Retterath-Borowski-Weimer combination cannot satisfy claim 44(f), because none of the references in the combination provide any teachings that would satisfy claim 44(f) as properly understood.

C. Ground 1C: Claims 44, 45, 48, and 50 over Retterath, Borowski, and Hipp

159. In my opinion, a POSITA would not have been motivated to combine Retterath, Borowski, and Hipp—and the combination does not satisfy the requirements of claim 44(c), 44(e), or 44(f). Accordingly, it is my opinion that neither claim 44 nor claims 45, 48, or 50 that depend from claim 44 are obvious in light of the Retterath-Borowski-Hipp combination.

1. Claim 44

(a) A POSITA would not have been motivated to combine the Retterath, Borowski, and Hipp references

160. Dr. Shanley asserts that it would have been obvious to combine Retterath, Borowski, and Hipp such that Retterath's system was implemented using Borowski's multi-SPAD pixels and Hipp's shadow mask. EX1003, ¶¶196-98. In my opinion, it would not have been obvious to a POSITA to use Hipp's shadow mask in a SPAD-based system.

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161. A POSITA would not have been motivated to implement Hipp's "shadow mask" with the Retterath-Borowski combination. In one embodiment of Hipp, the patent discusses implementing a "shadow mask" to only transmit light that is "incident on the active zones of the APDs." EX1007, 21:57-60. Hipp acknowledges that some of the light that passes through the shadow mask could be reflected by the photodetectors (APDs) and subsequently be reflected back from the lower side of the shadow mask and scattered, which could reach the "adjacent active zones" of the APDs and "act as an interference signal there." *Id.*, 22:1-7.

162. A POSITA would have understood that the SPADs in the proposed Retterath-Borowski combination are significantly more sensitive to noise and interference than the APDs described in Hipp. Indeed, unlike an APD, a SPAD is so sensitive that it can be triggered by a single photon. Dr. Shanley appears to agree with this understanding, cautioning that noise and interference in SPAD-based systems is "particularly problematic" because "even a single errant photon may cause a false positive detection, while also rendering the SPAD inoperable until it is quenched." EX1003, ¶55. Any errant photon reflected from the lower side of the shadow mask could trigger an adjacent SPAD, causing noise that would impact the system's ability to distinguish light relevant to the LIDAR system (e.g., light pulses from the system's emitters reflected from the field) from undesired reflections of light within the proposed Retterath-Borowski-Hipp combination.

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163. Dr. Shanley's discussion of the proposed combination of Hipp's shadow mask with proposed Retterath-Borowski combination does not address any of the potential interference issues that Hipp's shadow mask would cause in a system that uses sensitive SPADs for detectors. Indeed, a POSITA would have understood that the interference issues in a SPAD-based system are substantially heightened because of the sensitivity of SPADs. A POSITA would not have been motivated to implement Hipp's shadow mask in SPAD based system without making substantial modifications to the system to address the risk of interference from light scattered by the underside of Hipp's shadow mask. Indeed, Dr. Shanley does not discuss the risk of interference from the light scattered by the underside of Hipp's shadow mask in his proposed combination, nor does he discuss how to address the heightened risks of this interference when using sensitive SPADs as detectors. EX1003, ¶¶196-201. While Hipp discusses some potential methods of reducing reflections in a system with less sensitive APDs, including using light absorbing material on the underside of the shadow mask or configuring the system so that the shadow mask is at a 45 degree angle (EX1007, 22:7-10, 22:12-17; 22:18-30), Dr. Shanley does not address either of them in his obviousness analysis or whether such methods could be successfully implemented in a SPAD-based system.

164. Accordingly, in my opinion, no claims are unpatentable over the Retterath-Borowski-Hipp combination, because a POSITA would not have been

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motivated to make this combination.

(b) The Retterath-Borowski-Hipp combination does not satisfy "a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels" (claim 44(c))

165. Claim 44(c) of the '750 patent requires "a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel[.]"

166. Since Dr. Shanley does not appear to be asserting that the addition of Hipp changes anything about his Ground 1A analysis for claim 44(c) of the '750 patent, it is my opinion that Ground 1C fails to satisfy claim 44(c), for the same reasons I discussed above as to Ground 1A.

(c) The Retterath-Borowski-Hipp combination does not satisfy "a bulk transmitting optic disposed adjacent to the bulk imaging optic" (claim 44(e))

167. Claim 44(e) of the '750 patent requires: "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

168. Since Dr. Shanley does not appear to be asserting that the addition of

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Hipp changes anything about his Ground 1A analysis for claim 44(e) of the '750 patent, it is my opinion that Ground 1C fails to satisfy claim 44(e) for the same reasons I discussed above as to Ground 1A.

(d) The Retterath-Borowski-Hipp combination does not satisfy "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels" (claim 44(f))

169. Claim 44(f) of the '750 patent requires "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels."

170. Since Dr. Shanley does not appear to be asserting that the addition of Hipp changes anything about his Ground 1A analysis for claim 44(f) of the '750 patent, it is my opinion that Ground 1C fails to satisfy claim 44(f) for the same reasons I discussed above as to Ground 1A.

D. Ground 1D: Claims 44-48, 50 over Retterath, Borowski, Weimer, and Hipp

171. In my opinion, a POSITA would not have been motivated to combine

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Retterath, Borowski, and Hipp—and the combination does not satisfy the requirements of claim 44(c), 44(e), or 44(f). Accordingly, it is my opinion that neither claim 44 nor claims 45-48, and 50 that depend from claim 44 are obvious in light of the Retterath-Borowski-Weimer-Hipp combination.

1. Claim 44

(a) A POSITA would not have been motivated to combine the Retterath, Borowski, Weimer, and Hipp references

172. My analysis for Ground 1C that a POSITA would not have been motivated to combine Retterath, Borowski, and Hipp because of incompatibilities between Borowski's SPAD-based detectors and Hipp's noise-inducing shadow mask applies equally to the Retterath, Borowski, Weimer, and Hipp combination. Accordingly, it is my opinion that no claims are obvious over the Retterath, Borowski, Weimer, and Hipp combination.

(b) The Retterath-Borowski-Weimer-Hipp combination does not satisfy "a field of view that is non-overlapping <u>beyond a threshold distance</u> in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels" (claim 44(c))

173. Claim 44(c) of the '750 patent requires "a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical

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imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel[.]"

174. Since Dr. Shanley does not appear to be asserting that the addition of Weimer or Hipp changes anything about his Ground 1A analysis for claim 44(c) of the '750 patent, it is my opinion that Ground 1D fails to satisfy claim 44(c) for the same reasons I discussed above as to Ground 1A.

(c) The Retterath-Borowski-Weimer-Hipp combination does not satisfy "a bulk transmitting optic disposed adjacent to the bulk imaging optic" (claim 44(e))

175. Claim 44(e) of the '750 patent requires: "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

176. Since Dr. Shanley does not appear to be asserting that the addition of Weimer or Hipp changes anything about his Ground 1A analysis for claim 44(e) of the '750 patent, it is my opinion that Ground 1D fails to satisfy claim 44(e) for the same reasons I discussed above as to Ground 1A.

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(d) The Retterath-Borowski-Hipp-Weimer combination does not satisfy "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels" (claim 44(f))

177. Claim 44(f) of the '750 patent requires "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels."

178. It is my opinion that Ground 1D fails to satisfy claim 44(f) for the same reasons I discussed above as to Grounds 1A-1C.

E. Ground 2: Claims 44-48 and 50 over Imai, Higashi, and Grzesik

179. In my opinion, the Imai-Higashi-Grzesik combination does not satisfy the requirements of claim 44(c), 44(e), or 44(f). Accordingly, it is my opinion that neither claim 44 nor claims 45-48, and 50 that depend from claim 44 are obvious in light of the Imai-Higashi-Grzesik combination.

1. Claim 44

(a) The Imai-Higashi-Grzesik combination does not satisfy "a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels" (claim 44(c))

180. Claim 44(c) of the '750 patent requires "a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel[.]"

181. For the requirement that the field of view of each pixel is "non-overlapping beyond a threshold distance in a field external to the optical imaging system" with the fields of view of all other pixels, no threshold distance is disclosed in the Imai-Higashi-Grzesik combination.

182. Dr. Shanley provides nothing but conclusory opinions that Imai discloses pixels with a field of view non-overlapping beyond a threshold distance. EX1003 ¶¶222, 226. However, when asked in deposition about the threshold distance disclosed by Imai, Dr. Shanley indicated that it was "not a quantifiable number." EX2010, 99:4-100:2.

183. Accordingly, it is my opinion that the Imai-Higashi-Grzesik

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combination does not satisfy claim 44 of the '750 patent, because there is no "threshold distance" beyond which the fields of view of pixels are non-overlapping.

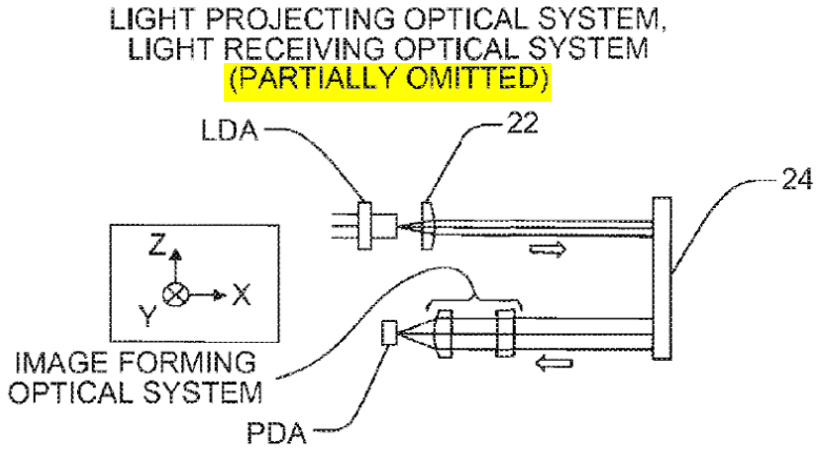
(b) The Imai-Higashi-Grzesik combination does not satisfy "a bulk transmitting optic disposed adjacent to the bulk imaging optic" (claim 44(e))

184. Claim 44(e) of the '750 patent requires: "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

185. In my opinion, the Imai-Higashi-Grzesik combination does not satisfy the requirement of a bulk transmitting optic disposed "adjacent to" the bulk imaging optic. Dr. Shanley points to Figure 2C as support for his opinion that Imai discloses a bulk transmitting optic disposed adjacent to the bulk imaging optic. Specifically, Dr. Shanley points to the lenses shown in Figure 2C as the bulk transmitting optic and the bulk imaging optic. Dr. Shanley's opinion that Imai discloses that these lenses are "adjacent to" each other is based solely on the fact that these lenses appear to be near each other in Figure 2C.

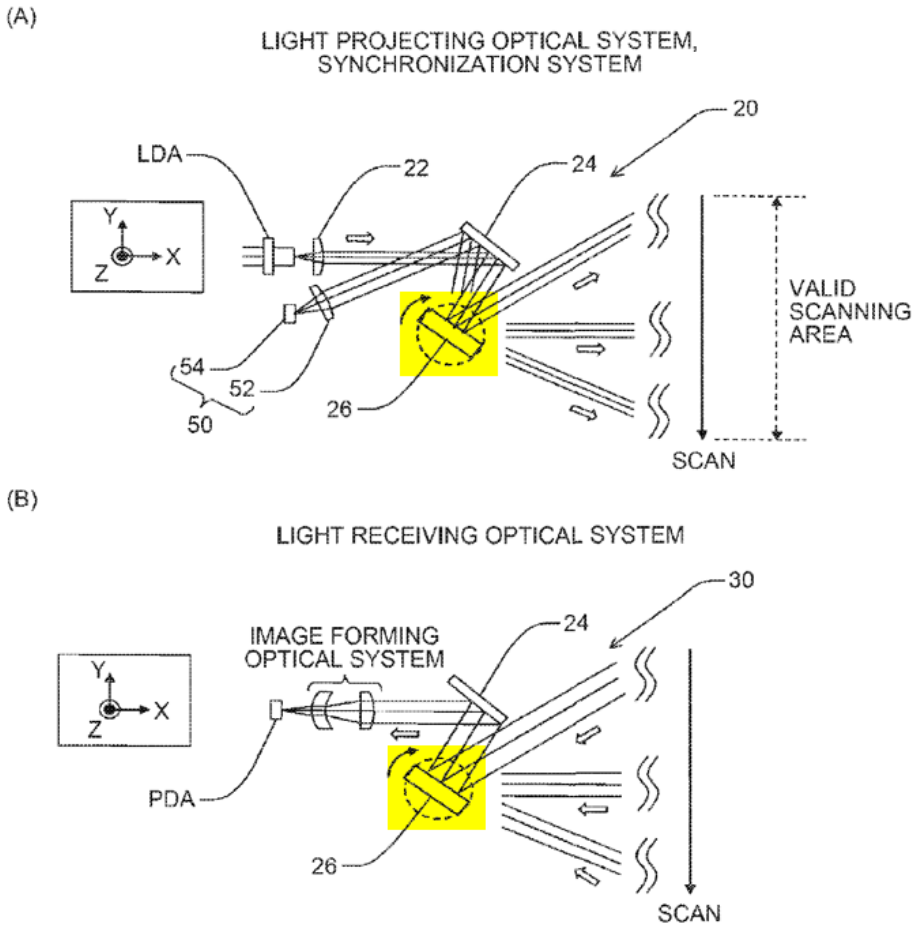
186. However, in my opinion, a POSITA would not have understood based on Figure 2C that the lenses Dr. Shanley is pointing to are "adjacent to" each other. Figure 2C indicates that it is "partially omitted":

(C)

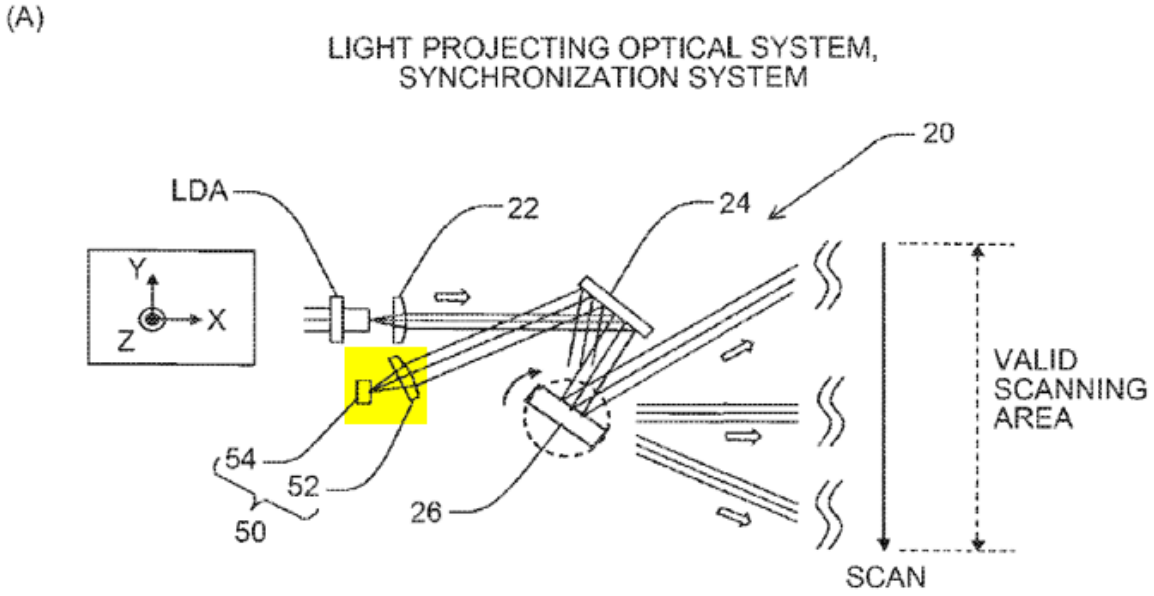


EX1009, FIG. 2C (highlighting added). In other words, a POSITA would have understood that Figure 2C is not an accurate reflection of the spatial relationships between elements in the Imai system.

187. Dr. Shanley testified that "a lot" is omitted from Figure 2C, including the elements shown in Figures 2A and 2B. EX2010, 88:7-90:8. For example, Dr. Shanley testified that element **26** shown in Figures 2A and 2B is included in what is "partially omitted" from Figure 2C. *Id.*, 89:11-90:8. Figures 2A and 2B are reproduced below, with element **26** highlighted:



EX1009, FIGS. 2A-B (highlighting added). Further, Dr. Shanley testified that "everything to the left of" element **24** in Figures 2A and 2B is omitted from Figure 2C. EX2010, 90:3-8. For example, synchronization system **50** appears in Figure 2A, but is omitted from Figure 2C:



EX1009, FIG. 2A (highlighting added). Dr. Shanley further testified that Figure 2C is "just a sketch basically." EX2010, 90:9-21.

188. Consistent with Dr. Shanley's testimony, it is my opinion that a POSITA would have understood that the "partially omitted" material from Figure 2C includes the elements shown in Figures 2A and 2B. Figure 2A and 2B are presumptively complete—given Figure 2C's indication that it is "partially omitted." Further, Figures 2A and 2B show several additional elements not shown in Figure 2C—and they provide *no* suggestion that the receive-side or transmit-side lenses have *any* spatial relationship to each other, let alone a proximate one. As a result, I agree with Dr. Shanley that Figure 2C is nothing more than a sketch—and a POSITA would not have relied on Figure 2C in determining the spatial relationship between the components shown in Figure 2C.

189. As a result, it is my opinion that a POSITA would not have considered Figure 2C to disclose "a bulk transmitting optic disposed adjacent to the bulk imaging optic." A POSITA would have understood that the addition of the "partially omitted" elements to the Figure 2C system would have changed the spatial relationship between the components, such that it would not be accurate to rely on illusory spatial relationships suggested by Figure 2C.

190. Dr. Shanley cites to other of Imai's disclosures in contending that Imai satisfies claim 44(e) of the '750 patent. EX1003, ¶233 (citing, *e.g.*, EX1009, [0038], [0039], [0041]. But none of these disclosures indicate any spatial proximity between the lenses Dr. Shanley identifies in Imai for claim 44(e). Further, Dr. Shanley testified in his deposition that Imai is a "rough translation." EX2010, 92:17. Additionally, Dr. Shanley testified that in his view, Imai's wording is not accurate. For example, Dr. Shanley testified that in his opinion, a better word for "overlapping" in Imai's paragraph [0039] would be "coincident." *Id.*, 95:20-97:10. In my opinion, Dr. Shanley's testimony regarding the flaws in Imai's disclosures provide further support for my view that a POSITA would not have understood Imai to disclose "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

191. Accordingly, it is my opinion that the Imai-Higashi-Grzesik combination does not satisfy claim 44(e) of the '750 patent.

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(c) The Imai-Higashi-Grzesik combination does not satisfy "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels" (claim 44(f))

192. Claim 44(f) of the '750 patent requires "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels."

193. It is my opinion that the Imai-Higashi-Grzesik combination does not satisfy claim 44(f) of the '750 patent, because it does not disclose that the electromagnetic radiation output from each emitter is coincident with a field of view of a corresponding pixel in the plurality of pixels, as properly understood.

194. As I discussed above, it is my opinion that a POSITA would have understood the claim limitation "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel"in claim 44(f) to mean that the electromagnetic radiation output from each emitter in the illumination pattern and the field of view of a corresponding pixel cover substantially the same area in the field. *See supra* Section VII.A. I also discuss

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above that I disagree with Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim term, which appears to be that the direction or axis of an emitter matches the direction or axis of a corresponding pixel. *Id.* Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" term only takes account of the *direction* of the radiation outputs and detector fields of view—not the *area*—which in my view is incorrect.

195. Dr. Shanley relies on the disclosures of Imai for claim 44(f) of the '750 patent. EX1003, ¶¶236-39. Specifically, Dr. Shanley relies on Imai's disclosures for the embodiment shown in Figure 10 indicating that the "irradiation range" of its laser diodes (LDs) "correspond[]" to the "light receivable ranges" of a corresponding pixel or pixels. *Id.*, ¶¶ 237-38 (citing, *e.g.*, EX1009, [0099], [0125]). But Dr. Shanley acknowledges that Imai discloses that "[t]he irradiation range of each LD is set to be slightly larger than corresponding light receiving ranges of the four PDs." EX1003, ¶237 (citing EX1009, [0101]). Accordingly, it appears that Dr. Shanley's opinion that Imai satisfies the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" limitation of claim 44(f) depends on his understanding that the claim limitation

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merely requires *any* overlap between a radiation output in the illumination pattern and the field of view of a corresponding detector (which is incorrect in my view).

196. Imai discloses that it is important for the irradiation range of each LD to be *larger* than the receiving range of each group of PDs. Imai discloses:

> **The irradiation range of each LD is set to be slightly larger than corresponding light receiving ranges of the four PDs.** According to this, it is possible to efficiently irradiate the light receivable range, so that a light reception quantity in the light receivable range may be increased and detection accuracy and a detection distance may be improved. **It is possible to inhibit deterioration in detection accuracy and detection distance even when the irradiation range and the light receivable range are slightly displaced with each other within a manufacturing range.**

EX1009, [0101] (emphasis added). A POSITA would have therefore understood that using irradiation ranges in Imai's system that are *larger* than the corresponding receiving ranges was important to ensuring detection efficiency, accuracy, and distance. *Id.*

197. In my opinion, Imai does not disclose that the electromagnetic radiation from each of its emitters in the Figure 10 embodiment is coincident the field of view of a corresponding pixel. Rather, as Dr. Shanley acknowledges, Imai discloses that the irradiation range of each of its emitters is "larger" than the "corresponding light receiving ranges" of the detectors. EX1009, [0101]. In my view, this means that

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Imai does not meet the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" limitation of claim 44(f), since the radiation outputs of emitters in Imai do not cover substantially the same area in the field as the field of view of their corresponding pixels.

198. Dr. Shanley also relies on the Figure 11 embodiment of Imai as a "second manner" of allegedly satisfying claim 44(c). EX1003, ¶238. Imai discloses that the Figure 11 embodiment is a "second modification" substantially related to Imai's Figure 10 "first modification" embodiment. EX1009, [0125].

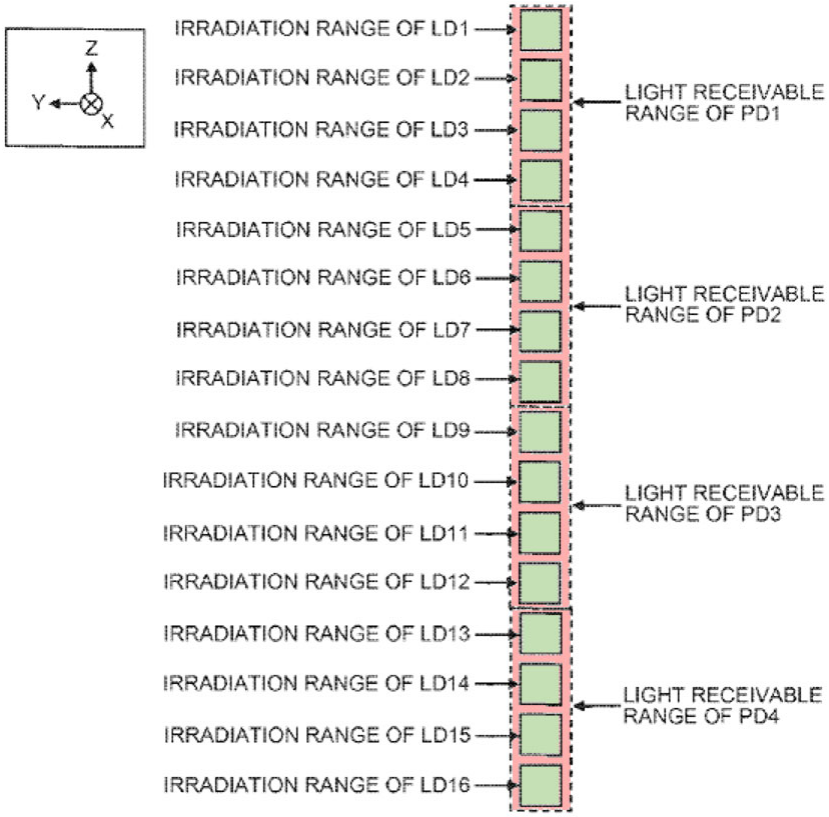
199. Imai does not disclose any details for the relationship between irradiation and detection regions for the Figure 11 embodiment—let alone that the irradiation and detection regions are substantially the same per the requirements of claim 44(f). Given Imai's teachings about the advantages associated with irradiation regions that are *larger* than corresponding detection regions and Imai's discussion of the close relationship between the Figure 10 and 11 embodiments, a POSITA would have understood that the irradiation regions in Imai's Figure 11 embodiment are larger than the detection regions. Accordingly, in my opinion, Imai's Figure 11 embodiment does not satisfy the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" limitation as properly understood, for the same reason I discuss above for the Figure

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10 embodiment.

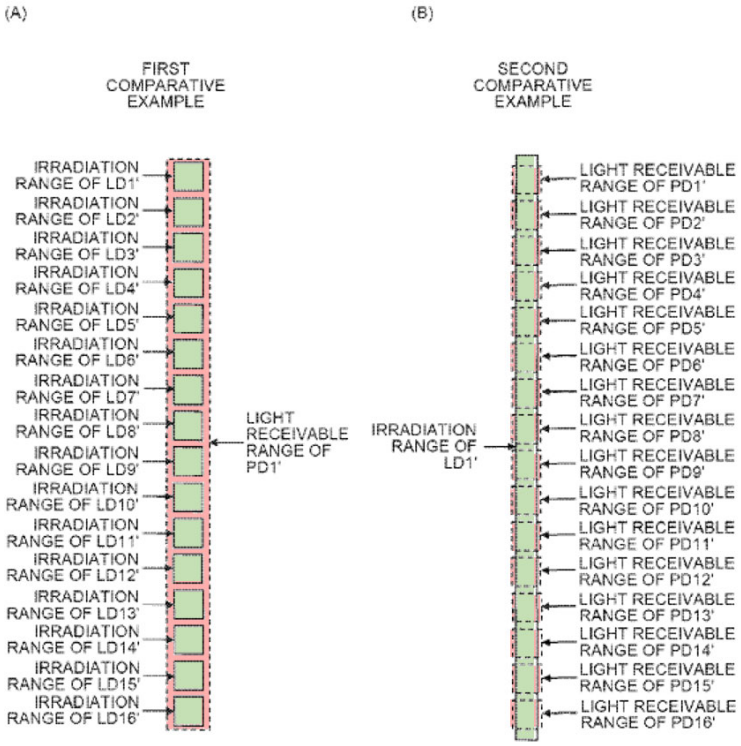
200. Imai consistently discloses embodiments in which irradiation ranges and receiving ranges cover *different* areas of the external field. For example, I provide annotated versions of several of Imai's figures below, with green highlighting showing irradiation ranges and pink highlighting indicating receiving ranges:

FIG.5



EX1009, FIG. 5 (highlighting added), [0062].

FIG.7



Id., FIG. 7 (highlighting added), [0016], [0067]-[0069].

201. Accordingly, it is my opinion that the Imai-Higashi-Grzesik combination does not satisfy the requirements of claim 44(f).

F. Ground 3: Claims 44-48 and 50 over Weimer, Borowski, and Hipp

202. In my opinion, a POSITA would not have been motivated to combine Weimer, Borowski, and Hipp—and the combination does not satisfy the requirements of claim 44(c), 44(e), or 44(f). Accordingly, it is my opinion that neither claim 44 nor claims 45-48, and 50 that depend from claim 44 are obvious in light of the Weimer-Borowski-Hipp combination.

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1. Claim 44

(a) A POSITA would not have been motivated to combine the Weimer, Borowski, and Hipp references

203. My analysis for Ground 1C that a POSITA would not have been motivated to combine Retterath, Borowski, and Hipp because of incompatibilities between Borowski's SPAD-based detectors and Hipp's noise-inducing shadow mask applies equally to the Weimer, Borowski, and Hipp combination. Accordingly, it is my opinion that no claims are obvious over the Weimer, Borowski, and Hipp combination.

(b) The Weimer-Borowski-Hipp combination does not satisfy "a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels" (claim 44(c))

204. Claim 44(c) of the '750 patent requires "a plurality of pixels arranged behind the bulk imaging optic, wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) and has a field of view that is non-overlapping beyond a threshold distance in a field external to the optical imaging system with fields of view of all other pixels in the plurality of pixels, and wherein the plurality of pixels includes at least a first pixel and a second pixel[.]"

205. For the requirement that the field of view of each pixel is "non-overlapping beyond a threshold distance in a field external to the optical imaging

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system" with the fields of view of all other pixels, no threshold distance is disclosed in the Weimer-Borowski-Hipp combination.

206. In his report, Dr. Shanley only provides his conclusory opinion that Weimer's disclosures satisfy the "beyond a threshold distance" limitation. EX1003 ¶271. However, in deposition, Dr. Shanley testified that he "can't quantify" the threshold distance in Weimer's system. EX2010, 115:8-11.

207. Accordingly, it is my opinion that the Weimer-Borowski-Hipp combination does not satisfy claim 44 of the '750 patent, because there is no "threshold distance" beyond which the fields of view of pixels are non-overlapping.

(c) The Weimer-Borowski-Hipp combination does not satisfy "a bulk transmitting optic disposed adjacent to the bulk imaging optic" (claim 44(e))

208. Claim 44(e) of the '750 patent requires: "a bulk transmitting optic disposed adjacent to the bulk imaging optic."

209. Pointing to Figure 3A of Weimer, Dr. Shanley opines that "Weimer provides a bulk transmitting optic (e.g., transmit optic 318) that transmits light beams 208 to the surrounding environment and disposed adjacent to the bulk transmit optic 31." EX1003, ¶277. Dr. Shanley does not even attempt to identify a bulk imaging optic. He only identifies a "bulk transmitting optic" and a "bulk transmit optic." *Id.* Further, Dr. Shanley identifies an element—"bulk transmit optic 31"—that does not appear in Figure 3A at all.

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210. In my opinion, Weimer does not satisfy the limitation "a bulk transmitting optic disposed adjacent to the bulk imaging optic." EX1001, claim 44. The only disclosures from Weimer Dr. Shanley appears to rely are those relating to Figure 3A of Weimer. But a POSITA would not have understood Figure 3A was to scale or that it could be relied on to understand the spatial relationship between various elements in Weimer's system. Dr. Shanley appears to agree with me. When asked in deposition if Figure 3A of Weimer was "to scale," Dr. Shanley testified: "I have no idea." EX2010, 108:18-20.

211. Accordingly, it is my opinion that the Weimer-Borowski-Hipp combination does not satisfy claim 44(e) of the '750 patent.

(d) The Weimer-Borowski-Hipp combination does not satisfy the claim 44(f) requirement that "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels"

212. Claim 44(f) of the '750 patent requires "a plurality of emitters arranged to project electromagnetic radiation through the bulk transmitting optic and into the field according to an illumination pattern where electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel in the plurality of pixels."

213. It is my opinion that the Weimer-Borowski-Hipp combination does not satisfy claim 44(f) of the '750 patent, because it does not disclose that the

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electromagnetic radiation output from each emitter is coincident with a field of view of a corresponding pixel in the plurality of pixels, as properly construed.

214. As I discussed above, it is my opinion that a POSITA would have understood the limitation "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" in claim 44(f) to mean that the electromagnetic radiation output from each emitter in the illumination pattern and the field of view of a corresponding pixel cover substantially the same area in the field. *See supra* Section VII.A. I also discuss above that I disagree with Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" claim limitation, which appears to be that the direction or axis of an emitter matches the direction or axis of a corresponding pixel. *Id.* Dr. Shanley's apparent understanding of the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" limitation only takes account of the *direction* of the radiation outputs and detector fields of view—not the *area*—which in my view is incorrect.

215. Dr. Shanley relies on the disclosures of Weimer to show that the Weimer-Borowski-Hipp combination satisfies claim 44(f). EX1003 ¶279. For example, Dr. Shanley relies on Weimer's Figure 2A, reproduced below:

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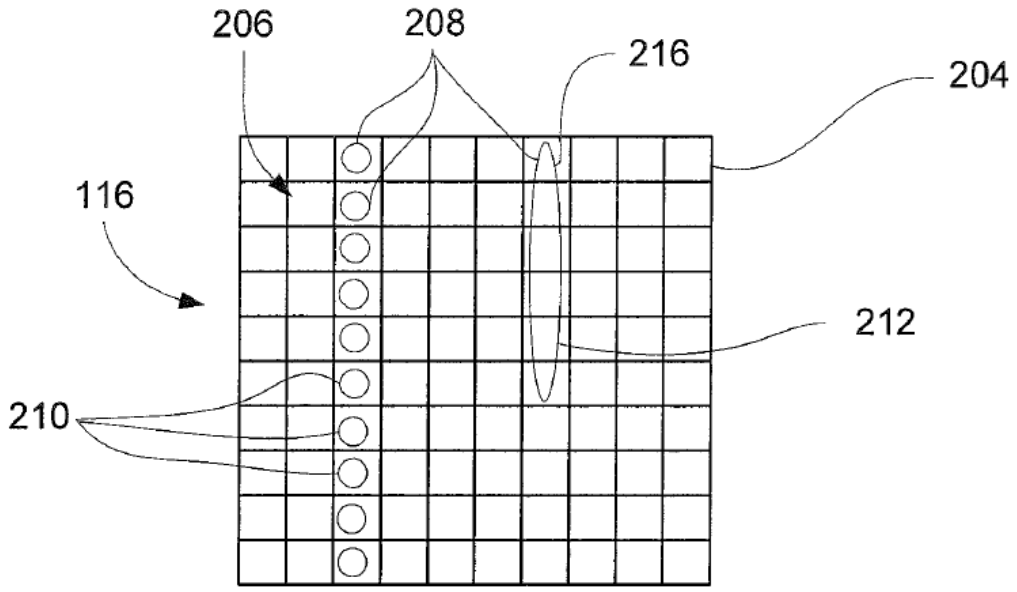


Fig. 2A

(EX1003, ¶279 (EX1008, FIG. 2A).)

216. However, it is my opinion that Weimer does not disclose that electromagnetic radiation output from each emitter is coincident with a field of view of an alleged corresponding pixel, as properly construed. In other words, Weimer does not disclose that electromagnetic radiation output from each emitter covers substantially the same area in the field as the field of view of an alleged corresponding detector. Rather, Weimer discloses that the area of the field illuminated by each emitter is substantially *smaller* than the field of view of a corresponding detector. As a result, Weimer does not disclose that the electromagnetic radiation output from each emitter is coincident with a field of view of a corresponding pixel, per the requirements of claim 44(f).

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217. Each of Weimer's emitters illuminates an area of the external field smaller than the field of view of one of its detectors. This can be seen in Figure 2A that Dr. Shanley relies on for his opinion. I have provided an annotated version below that shows the substantial differences between emitter spot size and detector field of view:

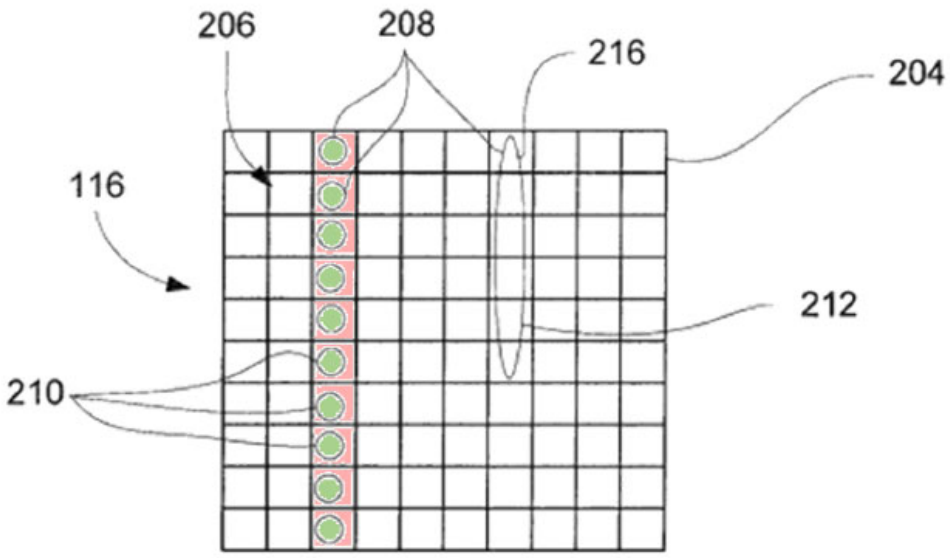


Fig. 2A

(EX1008, FIG. 2A (highlighting added).)

218. Weimer discloses the use of smaller emission regions is an important feature of its system, indicating that "[w]ithin the field of view, the goal for good daytime performance has been to have the laser spot size only slightly smaller than the receiver's instantaneous field of view." EX1008, 1:56-59. A POSITA would have understood that the laser spot size is significant, as shown in the many Weimer

figures (some annotated examples of which are provided below) that show substantial differences between emitter spot size and detector field of view:

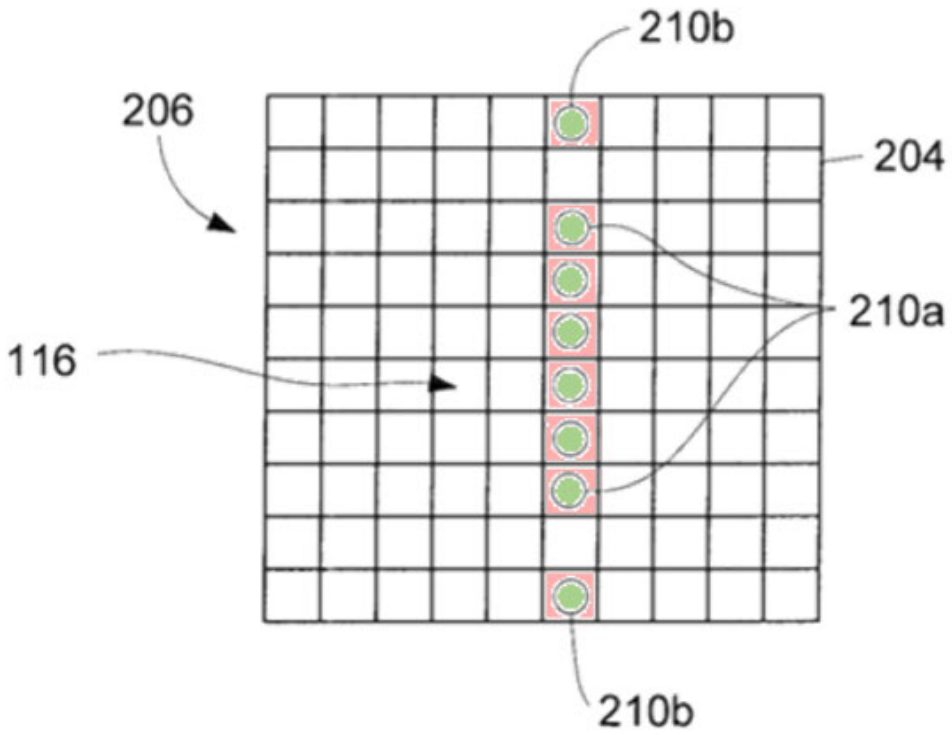
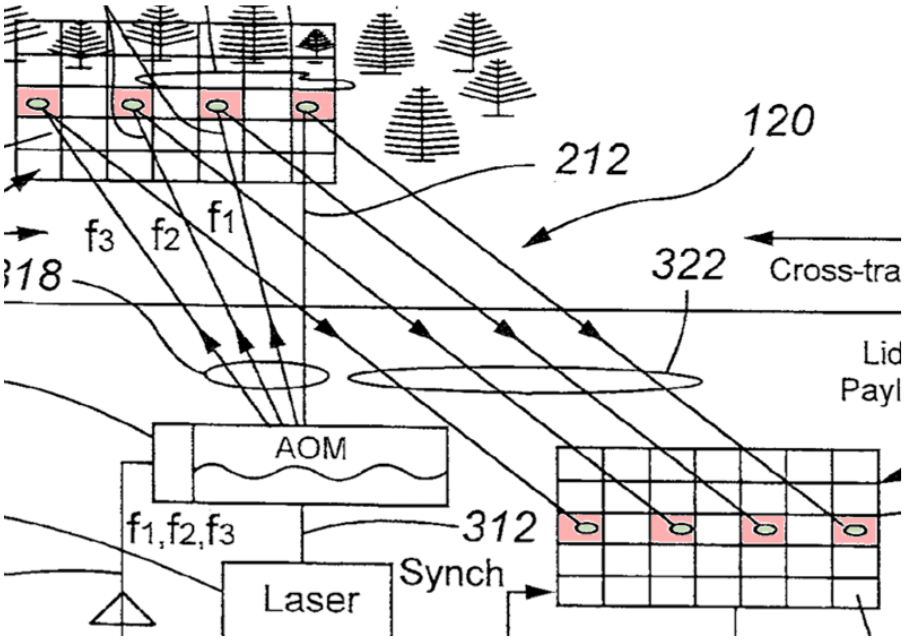


Fig. 2D

EX1008, FIG. 2D (highlighting added); *see also id.*, FIGS. 2A-C, 2E-J.



EX1008, FIG. 3A (excerpt; colored annotations added).

219. Accordingly, it is my opinion that the Weimer-Borowski-Hipp combination does not satisfy the "electromagnetic radiation output from each emitter in the illumination pattern is coincident with a field of view of a corresponding pixel" limitation of claim 44.

IX. SECONDARY CONSIDERATIONS

220. I understand that there are certain secondary considerations of nonobviousness that are relevant to the determination of invalidity based on obviousness over the prior art. I provide my opinions as to these secondary considerations below.

A. Skepticism

221. I understand that industry skepticism is a secondary consideration of

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nonobviousness.

222. It is my opinion that there was significant industry skepticism about the use of SPADs in a LIDAR device prior to the ’750 patent.

223. Such industry skepticism is supported, for instance, by Dr. Shanley’s testimony. Dr. Shanley testified that he could not identify a single LIDAR system—commercial or noncommercial—that used SPADs prior to U.S. Patent No. 11,175,405 (the “’405 patent”)—another Ouster patent at issue in a co-pending IPR, and which was filed after the ’750 patent. EX2015, 77:1-8, 79:2-80:16.

224. Further, Dr. Shanley testified that while he was aware of SPADs as of the 1990s, he never incorporated them into a system he worked on, including any of the LIDAR systems he worked on. EX2015, 12:18-22, 14:13-15:5.

225. Dr. Shanley additionally testified that in at least one instance, he specifically recalls choosing to use photodiodes as the photodetectors of a LIDAR system instead of SPADs. EX2015, 16:20-17:1. Dr. Shanley testified that his team did not use SPADs in the system 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. Further, Dr. Shanley testified that his team needed something that, unlike SPADs, was “very simple” and “very fast and very quick and very reliable.” *Id.*, 18:10-15. Since photodiodes were “cheap” and an “off-the-shelf array,” Dr. Shanley’s team decided to use photodiodes in the system rather than SPADs. *Id.*, 17:6-12.

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226. Further, Dr. Shanley testified that he could not identify any LIDAR system sold prior to the ’405 patent that used SPADs. EX2015, 77:1-8. While Dr. Shanley suggested that there were noncommercial uses of SPADs in LIDAR systems prior to the ’405 patent, when questioned on specifics, he made it clear that this was based solely on assumptions and his “gut feeling” based on trends in the last three or four years (long after the ’750 patent’s priority date):

> Q. Dr. Shanley, you mentioned that you weren't aware of any commercial LiDAR devices that use SPADs prior to the ’405 patent; is that correct?
>
> A. Yes.
>
> MR. HAGIZ: Objection to form.
>
> Q. But you indicated that there were possibly some noncommercial LiDAR devices prior to the ’405 patent that use SPADs; is that correct?
>
> A. Yes.
>
> Q. So what were those devices?
>
> A. I would assume that a lot of people doing the geophysical imaging and NASA programs and things like that have gravitated to using SPADs.
>
> Q. So you said you assume that those systems use SPADs?
>
> A. I would think so.
>
> Q. What’s your basis for thinking that?

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A. They're more sensitive detectors. And I might say also, the commercial availability of the arrays -- because Sony and Osram and a whole bunch of people are now supplying SPADs, SPAD arrays.

Q. And you say now supplying SPAD arrays, Sony, Osram. I mean, do you know how long they've been providing SPAD arrays?

A. I would assume over the last three or four years, though I don't know that's true. We could go back and compile a history. But it's just my gut feeling that that technology has really matured to be cheap and off-the-shelf -- though prior to that people probably –

You know, if I needed a SPAD array and it wasn't available, I would go directly to the manufacturer and fund a program to actually build me these detectors for a specific application.

Q. So can you name a specific system prior to the '405 patent that used SPADs in a LiDAR system?

A. Not at this point.

EX2015, 79:2-80:16.

227. In his testimony for the present *inter partes* review proceeding, Dr. Shanley provided further testimony regarding limitations of SPADs prior to the '750 patent. For example, Dr. Shanley provided the following testimony indicating that SPADs were incompatible with certain wavelengths of light:

Q. Okay. Are you aware of any

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commercial systems that used SPADs for LiDAR prior to the challenged patents?

MR. DEUTSCH: Objection. Form and scope.

A. It's a hard question to answer.

You know, going back and looking at stuff, I just assumed that some systems were, you know,

Q. But you chose not to put SPADs in the systems; isn't that correct?

MR. DEUTSCH: Objection. Form.

Scope.

A. Our system requirements were such that the particular wavelengths that were available at that time didn't suit themselves to SPADs, and a lot of the things I did with LiDAR systems in that timeframe were in the infrared, and we were also working down in the UV in the far blue area.

So that's not where a lot of the silicon-based, you know, the current SPADs we're talking about were available.

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Q. And why is that?

MR. DEUTSCH: Objection. Form.

Scope.

A. Because the detector wavelength and sensitivity that we needed, and there were specialized systems.

Q. What about those wavelengths that you just mentioned were not a good fit for a system that used SPADs?

MR. DEUTSCH: Objection. Scope.

A. They couldn't detect the radiation that we were interested in. They weren't sensitive in the ten micron region.

Q. SPADs were not; is that correct?

MR. DEUTSCH: Objection. Form and scope and mischaracterizes.

A. SPADs couldn't detect the 10.7 or 10.6 micron radiation.

Q. And why is that?

A. Bandgap of the semiconductor was too short or too small.

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Q. What is the bandgap of the

semiconductor?

MR. DEUTSCH: Objection. Scope.

A. Distance between the conduction

and valiant [sic] span of the semiconductor, which

dictates how the -- or the wavelength of

detection.

Q. So this was too short for --

strike that.

So the bandgap of the

semiconductor for SPADs was too short to detect

certain wavelengths that you work with?

MR. DEUTSCH: Objection. Form and

scope. Calls for speculation.

Hypothetical.

A. Bandgaps, let's see, it's a huge

explanation, and I don't think it's really

relevant. You have to go into the whole device

physics, and you have to fit the physics of the

particular device to the wavelength of light

that you're detecting.

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And so, the short answer, it was incompatible with the long wavelength device.

Q. So SPADs were incompatible with the long wavelengths that you were working with; is that correct?

MR. DEUTSCH: Objection. Form.

A. Yes.

MR. DEUTSCH: Mischaracterizes the testimony.

Q. What were the wavelengths that SPADs were incompatible with?

MR. DEUTSCH: Objection. Form and scope.

A. The patents disclose eye-safe wavelengths, and that's in the 1.3, 1.5 micron region.

Q. So wavelengths longer than that were incompatible with SPADs?

A. Yes.

MR. DEUTSCH: Objection. Scope.

A. Yes.

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(EX2010, 122:15-126:18.)

B. Failure of Others

228. The literature is replete with discussion of failures to use SPADs in LIDAR systems prior to the '750. For example, an article from years after the September 24, 2015 priority date of the '750 patent discloses repeated failures to develop practicable SPAD arrays. The article Sergey L. Vinogradov, "Evaluation of performance of silicon photomultipliers in LIDAR applications" discloses:

> 2D SPAD array/matrix could be applicable for a photon number resolving detection and it is considered as potentially an ideal photon detector due to the ability to readout every photon count timestamp asynchronously and independently due to direct access to every single SPAD in the array. **Regretfully, even mature CMOS technology does not resolve a problem of a low fill factor (ratio of sensitive area to the total area occupied by electronics for active quenching of Geiger discharge) of the front-side SPAD arrays.** For example, the recent development of MiSPIA (Microelectronic Single-Photon 3D Imaging Array) carried out by the world-recognized leaders in R&D of SPADs (Politecnico di Milano, Micro Photon Devices, Fraunhofer IMS) resulted in the fill factor of 3.14% for the 150 μm pitch 30 μm active area FrontSPAD array [20-21]. **Regretfully, an attempt to eliminate the fill-factor problem by using backside illuminated SPAD technology with SOI substrate introduced prohibitively high dark count rate (DCR) of about 240 Kcps for a single pixel of the 150 μm pitch 143 μm active area BackSPAD array**

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with the fill factor of 71.4% (about 40 times higher than DCR for the FrontSPAD. The better result (fill factor of 20% for the front-side SPAD array of 4x32 SPADs – so-called digital SiPM, dSiPM) has been reported by partially the same team (Politecnico di Milano, Micro Photon Devices) a year later [22].

Another approach to a SPAD array design has been demonstrated by Philips in their digital SiPM (dSiPM), where a direct access is provided to a sub-group of SPADs (sub-pixels of dSiPM) to reduce the number of electronic components and connections at the front-side area [23]. The fill factor of the dSiPM initially was achieved at the level of 50% (pixel size of 52 μm × 30 μm), i.e. about comparable with conventional analog SiPMs which fill factor is in a range of 30% - 80% depending on a pixel size. In the recent optimization of the dSiPM, the fill factor has been improved to 78% (pixel size of 59.4μm x 64μm) [24]. **However, 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.**

Therefore, to 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. In this situation, detailed analysis of the SPAD-based receivers is out of the scope of this paper.

EX2012 at 2-3 (emphasis added).

229. Dr. Shanley himself testified to the necessity of using ample supporting circuitry for SPADs like quenching circuits. Dr. Shanley testified that without such circuitry (which the Vinogradov indicates was a highly limiting factor in the use of SPAD arrays before the priority date of the '750 patent), he has seen SPAD-based systems fail dramatically:

> Q. So what happens with SPADs if you don't have a quenching circuit?
>
> A. Okay, I have a lot of experience with that. Initially –
>
> So you have this IV characteristic; okay? And if you start biasing here and you continue biasing –
>
> So what you have is current and voltage characteristic here, and this is voltage here, and this is current on this axis.
>
> So if you continue biasing -- and what happens is, when you operate down here, it's going to automatically increase to go to infinity. So what happens is this whips back to zero, and you may burn your diode out. You may just destroy it. I've seen things where they actually go into thermal runaway and all you have is a heated mess of semiconductor there. I've done many of those.

EX2011, 70:5-22.

230. Since the challenged claims all require photosensors made up of a plurality of SPADs, the repeated failure of others to develop SPAD arrays that could be used in a LIDAR system indicates that the challenged claims are not obvious over the prior art. *See, e.g.*, EX1001, claim 44.

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X. RESERVATION OF RIGHTS

231. The opinions and analyses in this report are based on currently available documents and information. Accordingly, I reserve my right to supplement and amend my opinions if additional information becomes available. Similarly, this report may be supplemented by testimony.

232. I also reserve the right to adjust or supplement my analyses in light of any rebuttal or alternative opinion advanced by the Petitioner.

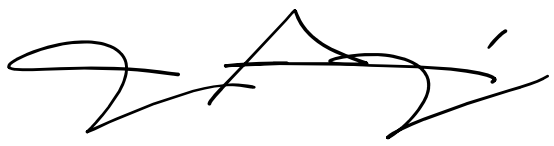
XI. CONCLUSION

233. In my opinion, claims 44-48 and 50 of the '750 patent are not invalid in light of the prior art grounds asserted by Dr. Shanley.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Dated: July 10, 2024

Respectfully submitted,



Jason A. Janét

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EXHIBIT A

Jason A. Janét, Ph.D.

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Raleigh, NC 27607
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Education

- Ph.D. Electrical & Computer Engineering, North Carolina State University, 1998
- M.S. Integrated Manufacturing Systems Engineering, North Carolina State University, 1994
- B.S. Mechanical Engineering, University of Virginia, 1990

Employment History

Applied Research Associates (ARA): 2018 - present

- **Corporate Director of IP and Product Commercialization (IP to Product—IP2P) | CTO-SSM:** Corporate/Business development, Intellectual Property Portfolio Build-out/Protection, and IP Transition to Product. Evaluate, quantify, present and recommend portfolios of IP, product lines and ventures on the basis of competitive landscapes, addressable markets, sales strategy, resource availability and technology readiness. Design, propose and mentor organizational structure(s), including cross-department and cross-sector relationships. Relevant technologies include medical technologies, augmented reality, non-GPS, synthetic environments, computer vision, machine intelligence, IoT sensors, robotics, automation, security, photogrammetry, weapons systems, unmanned systems, SaaS, BioTech, and precision agriculture for multiple market domains. Clearance Level: TOP SECRET & SCI.

DeltaFive: 2014 - 2018

- **CEO & Co-Founder:** Lead corporate, business, IP and technical development for spinout focused on IoT sensors, computer vision, machine intelligence, mobile robots, SaaS, and Lure Formulation for hospitality, pest, IT, and security markets. Strategic and tactical direction for sales, marketing and client services teams.
- **Inventor**: Three awarded patents (USPTO) and patents pending.
- **Board of Directors:** Serve on and report to Board of Directors, and chair the Technical Advisory Board.
- **See www.deltafive.com, https://jgc.outgrow.us/deltafive or www.youtube.com/watch?v=LoQe6_Lxprs.**

Transdigm [TDG] (Avionic Instruments | Acme Aerospace | Aerospace Cooling Solutions): 2002 – 2004, 2013 - 2014

- **VP/Director of Development** (2002-2004), **VP/Director of Sales, Program Management** (2013-2014). See www.transdigm.com, www.avionicinstruments.com, www.acme-aero.com, or www.aerospacecoolingsolutions.com.
    - Manage multiple product lines and cross-functional teams including product line managers (PLMs), account managers, inside sales, international sales, marketing, repair, engineers, technicians, distributors, legal, IP and rep organizations. (270 employees)
    - P&L, strategy, reporting, and forecasting for ~$105M/yr, 50% EBITDA, and 10% YOY growth.
    - Product lines comprised ~600 SKUs for advanced aerospace systems.
    - Epicor ERP for standard resource planning, including inventory optimization and workflow.
    - Change-Agent: Sikorsky S97/JMR programs and supply chain for Aerospace Cooling Solutions.
    - Incubation, launch, growth and exits for **ShelfWorks**, **VortexHC** and **RxMedic** (below).
- **Programs:**
    - **S97 Raider Light Tactical Helicopter –** Autonomy, power distribution and electrical system (PDES) for the Sikorsky S97 LTH, including FAA-compliant software development per DO-178B. (2013 – 2014) See http://www.youtube.com/watch?v=qy-Xb3X-bC0.
    - **Joint Multi-Role (JMR) Helicopter –** Leveraging S97, JMR employs a scaled-up level of autonomy/PDES for Sikorsky-Boeing team, under U.S. Army funding. (2014)
    - **Blue Fans –** Aerospace Cooling Solutions supply chain optimization. (2013 – 2014)
    - **DARPA Distributed Micro-Robotics** – PI/PM for "Mobile Robots that Climb Vertical and Inverted Surfaces." sponsored by DARPA – MTO. Develop mobile robots that climb walls and ceilings for surveillance, reconnaissance and breaching. Collaborated with Lockheed-Martin for automatic target recognition and Picatinny Arsenal for *Lamprey* SLAM holder. (2002 – 2004)

Teledyne Technologies [TDY]: 2011 - 2013

- **Senior Manager**

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- Lead cross-functional teams of scientists and engineers in CONUS
- M&A due-diligence, identification and recommendation (SeaBotix & BlueView)
- Lead contingents of cross-division teams to secure ~$352M in funding over 24 months.
- Plan and execute CRAD, business development and coordinate with strategic business units

- **ONR/USMC Cargo UGV** – PM for ONR/USMC-sponsored Cargo Unmanned Ground Vehicle (CUGV) Program subcontract (2011-2012). Manage team of engineers and scientists, in coordination with contract prime (Oshkosh) for unmanned combat vehicle control, perception and navigation. Multi-sensor suite included EO/IR Vision, LIDAR, IMU, and GPS.
- **Army LTL** – PM for Army-sponsored Lighten-the-Load (LTL) Program subcontract (2012-2013). Manage team to develop perception system comprised of stereo EO and stereo LWIR cameras to find and track leader(s), perform optical odometry, detect and map obstacles, and enhance SIGINT. Interface with sensors (LIDAR, IMU, GPS), autonomy for ATV-sized unmanned ground vehicles.
- **NASA ESP** – PM for RTP-based tasks for NASA Engineering Services and Prototyping demonstration (2012-2013). Provide Teledyne Engineering Services (lead), SAIC, Oceaneering, and Schafer with robot prototype and vision-based perception to detect, classify and track targets.
- **DARPA EXACTO** – PM for NC-based tasks for DARPA TTO Extreme Accuracy Tasked Ordnance (EXACTO) Program (2012-2013). Program developed first ever guided, small-caliber bullet with MEMS-based actuation, optical bullet tracking, optical target tracking, and bullet guidance to greatly improve accuracy and extend the day and nighttime range over current state-of-the-art sniper systems.
- **DARPA AngelFish/EagleRay** – PI/PM and inventor of the AngelFish Cross-Domain Submersible UAV, a man-portable, floodable airframe with tilt-thrusters capable of operating in and deliberately transitioning between the air, surface and underwater. Designed for optimal balance between hydro-/fluid-dynamics, materials, guidance/navigation/control, power conversion/storage, and perception for wing-in-ground flight.
- **Army PIRST** – Propose and capture the Pursuant In-stride Reconnaissance, Surveillance & Targeting (PIRST) program. By Army Night Vision & Electronics Sensors Directorate (NVESD) in 2013.

RxMedic Systems: 2003 – 2011 (*spinout from **Avionic Instruments***)

- **Co-Founder/General Manager/Board Member** (2004-2007), **CTO** (2007-2010), and **Director of Robotic/Automated Systems** post-acquisition by JM Smith (2010-2011).
  - Manage launch from **Avionic Instruments** (2004)
  - Build and lead nationwide growth of cross-functional teams to 75+ employees
  - Direct product development, manufacturing, field support, sales and marketing
  - Manage IP Portfolio & Legal: Patents include USPTO# 7,726,514 and 8,091,733
  - Oversee P&L, accounting, raising of capital, and accounts receivable
- **RxMedic ADS**: Invent, develop, market and support automated pharmacy dispensation and packaging systems for retail, hospital, mail order and industrial fulfillment organizations.
- **RxMedic ACS**: Integrate, refine, market and support automated pharmacy-counting systems for retail and hospital fulfillment organizations.
- Co-negotiated the acquisition of RxMedic Systems by JM Smith, Inc. in May of 2010, established RxMedic as a division, and coordinated 12-month transition. Supported evaluation and integration of automated systems for JM Smith business units including Smith Drug.

Vortex HC: 2002 - 2009 (*spinout from **Avionic Instruments***)

- **Vice President** (2004-2006), and **Facilities Security Officer (FSO)** (2005-2006)
  - Manage spin-out from **Avionic Instruments** (2004)
  - Lead cross-functional teams for product development, manufacturing, support, sales and marketing
  - Manage business and corporate strategy, execution, licensing, and ITAR/EAR-compliance
  - Support domestic and international legal and IP portfolio management, P&L, AP/AR
- **DARPA ARTEMIS** – PI and PM for "Vortex-Based AUVs for Counter-Mine and Counter-Obstacle Operations" sponsored by DARPA – ATO. Managed development of holonomic AUVs for landing on mines and performing soft-kill neutralization. Integrated CFD, rugged materials, MEMS-sensors for guidance, navigation and control. Collaborated with UT-ARL for development of circular synthetic aperture sonar and Teledyne RD Instruments for DVL. Developed high-precision acoustic underwater tracking system.
- **Products**: Managed development, manufacturing, world-wide marketing, and support of the following to military, law-enforcement, security, rescue, nuclear and entertainment customers:
  - VMRP Wall-Climbing Robot – Man-portable mobile robots that climb walls and ceilings.
  - Submersible Attractor – Rad-hardened attractor for nuclear energy market, BWR inspection
  - Submersible VMRP Robot – Man-portable underwater robots for bulkheads and tank interiors.

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- Lamprey SLAM Holder – Surface-agnostic instant placement mechanism for Picatinny Arsenal's Selectable Land- and Anti-personnel Mine (SLAM) breaching charge.

- **Licensing**: As part of exit strategy, instituted licensing and transition of VRAM technologies:
  - SeaBotix LBC – Little Benthic Crawler Remotely Operated Vehicle (ROV).
  - SeaRobotics HullBUG – Autonomous hull-grooming robot.
  - BDT – Attractors for high-speed, high-efficiency, low-overhead paper & fabric handling.
  - TMI – Attractors for inspection of nuclear boiler water reactor (BWR) facilities
- **ONR & NAVSEA HullBUG VRAM –** PI/Consultant for "Attractor Design for the Hull Biomimetic Underwater Grooming (HullBUG) Technology" and "HullBUG VRAM Design Optimization". (2006–2009).

ShelfWorks Technologies: 2002 – 2006 (*spinout from **Avionic Instruments***)

- **Charter Officer** (2004-2006).
  - Supported launch from **Avionic Instruments** (2002-2004)
  - Direct military product development, support commercial product development, sales & marketing
    - Bed, Bath & Beyond
    - Home Depot
  - Support IP Portfolio & Legal

Nekton Research (iRobot [IRBT]): 1998 - 2002

- **Vice President of R&D** (1998-2000) and **Director of Business Development** (2000-2002).
  - **Lead:** Cross-functional teams in marine-focused product/business development, production, deployment.
  - **IP Portfolio:** Co-inventor on USPTO# 6,378,801 (2002)
  - **Spinout:** Support incubation/launch of Parata Systems, a pharmacy automation company (1999-2002)
  - **M&A:** Provided early-stage due-diligence and introductions for acquisition by iRobot (2006)
- **Principal Investigator and Program Manager:**
  - **DARPA LSALS-SP3** – PI/PM for "3D Plume Tracing using Ranger™ MicroAUVs," sponsored by DARPA – MTO. Joint effort with Sandia National Labs, and Woods Hole Oceanographic Institute. Developed multiple collaborative MicroAUVs that search for and localize plume sources and aircraft blackbox, to rescue and/or recover humans and assets.
  - **DARPA Distributed Micro-Robotics** – PI/PM for "Swimming Arrays for Anti-Submarine Warfare", sponsored by DARPA – ATO. Joint effort with Draper Labs, Johns Hopkins University Applied Physics Lab, and Solers. Mobile acoustic array formations of multiple MicroAUVs. In contrast to towed arrays (e.g., TB-29), *Swimming Arrays* decouple tactical maneuvers from sensing maneuvers; enable protracted sensing, strong source direction discrimination, forward end-fire view, and dynamic array beamforming.
  - **DARPA Distributed Micro-AUVs** – PI/PM for "Aquatic Microbots", sponsored by DARPA – MTO. Under *Distributed Robotics* program, design, build and demonstrate ultra-small AUVs, called "MicroHunters™", which maneuver in 3D using only one moving part. Resulting navigation, called "Helical Klinotaxis" was validated on three different platforms and demonstrated to DARPA. Co-inventor on patent "3D Orientation for Aquatic Robots Using Helical Klinotaxis", USPTO in April 2002.
  - **Forensics ROV** – PM and inventor of porthole-size ROV to perform forensic analyses of sunken assets. Based on a diametrically-opposed, large-diameter, low-velocity, vector thrusters, provide underwater telepresence to search for remains, assets and root-cause indicators. Unique design minimized silt disturbance, and maximized options for ingress and egress. (Private customer)
  - **Deepwater Towfish** – 6500m depth-rated towfish to carry sensor suite for applications in energy sector, telecommunications sector, sub-bottom profiling, and terrain mapping. (Private customer – EdgeTech)
  - **DARPA APLA/MGM** – PI/PM for "MicroHunter Guidance and Control of 60mm Mortars", sponsored by DARPA – ATO. Under *Anti-Personnel Landmine Alternative/Minimally Guided Munitions* (APLA/MGM) program, collaborate with Battelle Memorial Institute to demonstrate feasibility, integrate microelectronic GNC sensors and actuators, and validate performance of single-actuator control force producer and guidance algorithm for indirect-fire munitions. Performance exceeded specifications.

Parata Systems: 1999 – 2002 (*spinout from **Nekton Research*** **serving as VP of Eng and Dir of BD**)

- Supported incubation and launch from **Nekton Research** (1999-2002)
- Robotic System for Retail & Mass-Fulfillment Pharmacy
- Technical & Business Development of Alpha- and Beta-level Products
- Supported initial IP Portfolio

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Duke University, Pratt School of Engineering: 1999 - 2021

- **Adjunct Associate Professor** (2005-2021) and **Adjunct Assistant Professor** (1999-2005).
  - Courses Taught Include:
    - Entrepreneurship & Tech Transition (Special Topics)
    - Robotics & Automation (MAE 442, ECE 383, ECE 142/442)
    - Control Theory (ECE 141/441)
- **MS Committee Member:** Serve on graduate student committees and advise research.
- **Advisor** and sponsor for Duke's Wall-Climbing Robot Team, which earned 1st place in the 2004 and 2005 International Climbing and Walking Robot (CLAWAR) Competitions in Madrid, Spain and London, England. Sponsored by the LORD Corporation and VortexHC.
- **Advisor** for Duke's DARPA Grand Challenge Team, in support of the Carnegie Melon Red Team(s), which earned 2nd and 3rd places. Perception included RADAR, LIDAR, IMUs and GPS.
- **Advisor** and sponsor for Duke's Autonomous Underwater Vehicle (AUV) team, which earned finalist standings five times in the AUVSI/ONR International Autonomous Underwater Vehicle Competition. Participated in multiple annual competitions since 2001, with the following rankings: 2nd in 2006, 4th in 2005, 5th in 2004, 3rd in 2003, 4th in 2002, and 7th in 2001. Sponsored by LORD, VortexHC, and SeaBotix.

North Carolina State University, School of Engineering: 1992 - 2021

- **Adjunct Assoc Professor** (2009-2020), **Board Integrated Manufacturing Systems Engineering Institute** (1998 – 2020), **Adjunct Asst Professor** (2000-2009), **Instructor** (1996-1999), **Researcher** (1992-1996).
  - Teaching Experience:
    - Robotics & Automation (ECE 444, ECE 591)
    - Control Theory (ECE 435)
    - Distributed (Non-Deterministic, Network- & Statistics-based) Controls (ECE 492Z)
  - **MS Committee Member:** Serve on graduate student committees, sponsor, and advise research.
  - **Advisor** & **Corporate Sponsor** for NCSU's Autonomous Underwater Vehicle (AUV) team, which began participating in the AUVSI/ONR International AUV Competition. Participated in 2005 and 2006.
- **NASA-HELIOS** – PM for development and demonstration of semi-autonomous robotic system for lunar habitation and transport. Under NASA's Exploration Office, and funding from United Technologies, Caterpillar, and North Carolina Space Grant Consortium. Managed team of 40+ people to build and competitively demonstrate lunar exploration and habitation mission including deployment of lunar lander, UGV, and personnel habitat modules. Mission was demonstrated in full and earned first place and NASA's *1998 Extra Terrestrial Award.* January 1996 to April 1998.
- **DARPA/ONR Outdoor Landmark Recognition** – Researcher for "Outdoor Landmark Recognition Using Hybrid Fractal Vision System and Neural Networks", by DARPA and ONR. Validate new approach to detecting and recognizing outdoor landmarks using the Region-Feature Neural Network. (1993–1996)
- **Other Systems***:* Bipedal robot (*Jenner*), a hexapod colony, an autonomous mobile robot (*Lazarus*), home automation & security based on decentralized control networks.

TMI Robotics: 1998 - 2013

- **President**
  - **Robotic & Automation Systems:** Submersible Robotic Hull Crawlers & Attractors for *General Electric*, *Hitachi*, *Framatome*/*Areva*, *SeaRobotics*, *SeaBotix*, etc. (2009-2018); wall-climbing robots for *SignalScape* (2009-2013); Pioneer mobile robot end-effector and bipedal robot for *Adept MobileRobots* (1998-2004); decentralized fuel pump control systems for *Gilbarco* (1998); Autonomous Following Golf Caddy for *Caddy Master* (1998-1999); Universal rotary actuator system for *Real World Interface* (*RWI*) and *iRobot* (*IS Robotics*) (1998-2000), etc.
  - **Artificial Intelligence Software and Textbook:** "Computational Intelligence: Supervised and Unsupervised Learning with Neural Networks", J.A. Janét and J.C. Sutton III. Copyright © 1998-2013. ISBN #0-9678493-0-6. Textbook included a time-limited single-user license for neural network software by TMI Robotics, Inc. Software included data, the Region-Feature Neural Network and the Hyper-Ellipsoid Clustering Neural Network for pattern analysis and machine intelligence. End-users/clients include *NCSU*, *National Technological University* (*NTU*) and *Video Based Engineering Education* (*VBEE*), IBM, etc.

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Other Professional Highlights:

- **Intellectual Property Litigation Expert Witness**: Provided reports, descriptive imagery and testimony for litigation regarding intellectual property, contracts and trade secrets. Cases are listed below, clients in **bold**:
  - A360 v **Toyota/Bastian** (2024-pres) [No. 1:23-cv-00198-JRS-TAB, Southern District of Indiana]
  - **Motive** v Samsara (2024-pres) [U.S. International Trade Commission]
  - **Good Sportsman** v Hangzhou ZH Tech [USPTO PTAB]
  - **Tesla** v Autonomous Devices (2024-pres) [USPTO PTAB (IPR)] '474 Patent
  - **Becton Dickenson v JFCRx** (2023-2024) [Contract, trade secret compliance/audit]
  - Juul v **NJOY** – (2023-pres) [ITC] and [District Court of DE]
  - Textron v **DJI** – (2023-2024) [Case No. 2:22-cv-351-RWS-RSP (E.D. Tex)]
  - Solmetex v. **Dental Recycling** (2023-pres) [Pre-IPR: USPTO]
  - **Daifuku** v. ControlLogix [Pre-IPR: USPTO]
  - Autonomous Devices v **Tesla** (2023-pres) [C.A. No. 22-1466 (MN), District Court of DE]
  - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01172] '583 Patent
  - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01055] '344 Patent
  - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01054] '974 Patent
  - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01169] '134 Patent
  - **Tesla** v Autonomous Devices (2023-2024) [USPTO PTAB IPR2023-01170] '449 Patent
  - **Tesla** v Autonomous Devices (2023-2024) [USPTO PTAB IPR2023-01171] '585 Patent
  - Autonomous Devices v **Tesla** (2023-pres) [Case No. 1:22-cv-01466, District Court of DE]
  - **Ouster** v. Hesai et al, Lidar Systems (2023-2024) [337-TA-1363, U.S. International Trade Commission]
  - **Ouster** v. Hesai et al, (2023-pres) [No. 1:23-cv-00406, District Court of DE]
  - **Boston Dynamics** v Ghost Robotics (2023-pres) [1:22-cv-01483-MN, District Court of DE]
  - Vivint v **SkyBell** Technologies (2022-pres) [2:21-cv-09472, Central Dist of DC]
  - Moog v **SkyRyse** (2022-2024) [1:22-cv-00187, Wester Dist of NY]
  - Velodyne v **Ouster** (2022-pres) [337-TA-1322, U.S. International Trade Commission]
  - **IQRIS** v Point Blank (2022-2023) [21-CV-61976-BB, Southern District of FL]
  - **Opex** v HC Robotics/Invata (2022) [337-TA-1293, U.S. International Trade Commission]
  - **iAqua** v Cayago (2022) [Reexam-EPR814 of 90/014,995 USPTO]
  - Cayago v **iAqua** (2022) [21-CV-61035, Southern District of FL]
  - Cayago v **iAqua** (2022) [Civil No. 21-1212, Puerto Rico]
  - Bacon Sons v **Perception Robotics** (2021-2022) [Case No: 30-2018-01000372, Orange Co, CA]
  - **AutoStore** v Ocado (2021-2023) [IPR2022-00443 USPTO]
  - **AutoStore** v Ocado (2021-2022) [IPR2022-00673 USPTO] (pre-institution)
  - **AutoStore** v Ocado (2021-2022) [IPR2021-00274 USPTO]
  - **AutoStore** v Ocado (2021-2022) [IPR2021-00311 USPTO]
  - **AutoStore** v Ocado (2021-2022) [IPR2021-00398 USPTO] (pre-lit)
  - **AutoStore** v Ocado (2021-2022) [IPR2021-00412 USPTO] (pre-lit)
  - **AutoStore** v Ocado (2021-2022) [PGR2021-00038 USPTO] (pre-lit)
  - **AutoStore** v Ocado (2021-2022) [HP-2020-000035, United Kingdom]
  - **AutoStore** v Ocado (2021-2022) [Spain – Pre-lit]
  - **AutoStore** v Ocado (2021-2022) [Case No. 2:20-cv-494, Eastern District of VA]
  - Ocado v **AutoStore** (2021-2022) [1-21-cv-00041, USDC - DNH]
  - Ocado v **AutoStore** (2021-2022) [1-21-cv-00806, USDC - DNH]
  - **iRobot** v SharkNinja (2021-2022) [337-TA-1252, U.S. International Trade Commission]
  - **Airborne Systems** v Wamore – Steerable parachute systems (2019-pres) [Arbitration – NJ]
  - **AutoStore** v Ocado (2020-2021) [337-TA-1228, U.S. International Trade Commission]
  - Interactive Play Devices v **Spin Master** (2020-2021) [Civil Action File No. 6:20-cv-00066, W.D. TX]
  - **DJI** v Autel – (2017-2021) RC UAV Systems [C.A. No. 16-706-LPS-CJB, District Court of DE]
  - Velodyne v **RoboSense** (2019-2020) [337-TA-1173, U.S. International Trade Commission]
  - Odyssey Marketing v **Spin Master** (2018) Unmanned Air Vehicles [IPR, USPTO]
  - Mattel v **Spin Master** (2018) Transformable Devices [IPR2018-01672, USPTO]
  - Mattel v **Spin Master** (2018) Transformable Devices [IPR2018-01673, USPTO]
  - Mattel v **Spin Master** (2018) Transformable Devices [IPR2018-01674, USPTO]
  - MPV v **DJI** – (2018) [Case No. 2:18-cv-02210-RGK-AGR, Central District Court of CA]
  - **Samsung** v Cywee – (2017) IMU Pose & AR [Case No. 2:2017cv00140, Eastern District of TX]

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- **DJI** v Autel – (2017-2018) [2:17-cv-00776-RAJ, Western District of WA]
- Synergy Drone v **DJI**– (2017-2018) [Case No. 1:17-cv-00242, TX Western District Court]
- **iRobot** v Bissell – (2017-2018) [337-TA-1057, U.S. International Trade Commission]
- **Hayward Industries** – (2015-2016) Evaluate IP and Enabling Technologies for Submersible Systems
- Choirock v **Spin Master** (2016-2018) Transformable Devices [Case No. IPR2017-00030, USPTO]
- **Spin Master** v Sphero, Inc. (2016-2017) [Case No. IPR2017-01272, USPTO]
- Sphero, Inc. v **Spin Master Ltd**. (2017) [New York Southern District Court, Case No. 1:17-cv-05428]
- Razor/Chen/Inventist v **Jetson Electric Bikes** (2016-2017) [337-TA-1000, U.S. Int. Trade Commission]
- Razor/Chen/Inventist v **Powerboard** (2016-2017) [337-TA-1000, U.S. International Trade Commission]
- Segway/DEKA/Ninebot v **Jetson** (2016-2017) [337-TA-1007, U.S. Int. Trade Commission]
- Segway/DEKA/Ninebot v **Powerboard** (2016-2017) [337-TA-1007, U.S. Int. Trade Commission]
- Segway/DEKA/Ninebot v **Jetson** (2016-2017) [337-TA-1021, U.S. Int. Trade Commission]
- Segway/DEKA/Ninebot v **Powerboard** (2016-2017) [337-TA-1021, U.S. Int. Trade Commission]
- **DJI** v Yuneec [No. 5:16-cv-595, U.S. District Court, Central District of CA]
- Rehco LLC v **Spin Master Ltd**. (2015-2020) [No. 1:2013cv02245, Northern District of IL]
- Segway/DEKA v **Ninebot** [Inv. No. 337-TA-935, U.S. International Trade Commission]
- Segway v **Shenzen Inmotion** – [Inv. No. 337-TA-935, U.S. International Trade Commission]
- ScriptPro v **Innovation** – Pharmacy Automation (2015) [2:06-cv-2468-CM-JPO U.S. Dist Court, KS]
- ScriptPro v **Innovation** – Pharmacy Automation (2011-2015) [06-2468-CM U.S. District Court, KS]
- Spinmaster v **YourStoreOnline** – Wall-Climbers (2009-2010) [CV 09-5803 CAS]
- SpinMaster v **YourStoreOnline** – RC Helicopters (2009-2010) [CV 09-2121 CAS]

- **Patent Inventorship:** Other patents pending
  - 6,378,801: Devices and methods for orienting and steering in three-dimensional space.
  - 7,726,514: Automated article dispensation mechanism.
  - 8,091,733: Automated article dispensation mechanism.
  - 8,751,035: Automated laundry drop-off and retrieval system.
  - 9,664,813: Automated Insect Monitoring
  - 9,999,211: Automated Insect Monitoring (Removable Chambers with Transparent Sides for Inspection)
  - 9,999,212: Automated Insect Monitoring (Signal Processing to Detect and Recognize Invasive Pest)
  - 11,382,324: Insect Traps and Monitoring System (IoT Monitoring System with Detect/Classify Ability)
- **Board of Directors/Advisors Experience:** Provide strategic technology, business and corporate expertise.
  - **Delta Five** – Distributed unattended sensors, automation, SaaS and IoT.
  - **Panacea BioMatx Inc** - Automated customized medications and nutraceuticals. (www.panacea.me)
  - **Lealear** – Automated storage and retrieval systems.
  - **RxMedic** – Automation for preparing prescription orders in retail, government, and hospital pharmacies.
  - **VortexHC** – Non-dexterous gripping, robot climbers (air and underwater), and 6DOF holonomic AUVs.
  - **NCSU Integrated Manufacturing Systems Engineering Institute** – Multi-disciplinary graduate school

Selected Publications (of ~40)

- IoT Solutions Enabling Hotelier's to Monitor for Bed Bugs, www.deltafive.com/wp-content/uploads/2018/06/DeltaFive_BedBugAwarenessWeek2018_PressRelease.pdf, June 2018.
- New York City Challenged by Bed Bugs, www.newswire.com/news/new-york-city-challenged-by-bed-bugs-delta-five-offers-green-solution-20043137, November 2017.
- On the Heels of the Largest Bed Bug Lawsuit Judgement, Delta-Five Has a Proven Green Solution for Hotels, www.newswire.com/news/on-the-heels-of-the-largest-bed-bug-lawsuit-judgement-delta-five-has-a-19990567, October 2017.
- Hoteliers Find Delta Five's Innovative Bed Bug Solution Catches Bugs Faster and More Consistently, www.newswire.com/news/hoteliers-find-delta-fives-innovative-bed-bug-solution-catches-bugs-19940513, September 2017.
- As Hoteliers Look to Combat Bed Bug Rise Delta Five Offers Researched Solution, www.newswire.com/news/as-hoteliers-look-to-combat-bed-bug-rise-delta-five-offers-researched-19846348, August 2017.
- Green Approach to Prevention and Early Detection, www.eprnews.com/delta-five-highlights-green-approach-to-prevention-and-early-detection-during-bed-bug-awareness-week-138925/, June 2017

- Delta Five Raises the Bar in Battle Against Bed Bugs, www.newswire.com/news/delta-five-raises-the-bar-in-battle-against-bed-bugs-19547330, May 2017.
- Automated Bed Bug and Insect Monitoring System, www.newswire.com/news/delta-five-launches-automated-bed-bug-and-insect-19224593, April 2017.
- "Think It, Build It, Win It: Vision-Based Robot Design Secures Teledyne a $350M NASA Engineering Contract" H. Neale. *NASA Tech Briefs* 2013/2014.
- "Automation is Changing Pharmacy: How Reducing Repetition Behind the Counter Improves Over the Counter Care" J. Janét. October 2010. *Insight Magazine.*
- "Automate Your Profits" J. Janét. October 2009. *Insight Magazine.*
- DTIC #ABV 299170 (NATICK/TR-04/013L): "Vortex Regenerative Air Movement: Attraction and Attachment on Vertical and Inverted Surfaces— A Simple Method for Static and Mobile Robots for Climbing Walls and Ceilings" J. Janét, D. Reinfeld, B. Wiedeman. October 2003. (Contract No. DAAD16-00-C-9259; US Army Soldier Systems Command, Natick, MA)
- DTIC #AD B267 288 (NATICK/TR-01/009L): "MicroHunter Control Applications for Elimination of Anti-Personnel Landmines: Low-Cost, Minimally Guided Munitions – A Simple Method for Controlling the Trajectory of Spinning Projectiles" M. Kemp, J. Janét, and C. Pell. May 2001. (Contract No. DAAN02-98-C-4030; US Army Soldier Systems Command, Natick, MA)
- "Development of a Micro Autonomous Underwater Vehicle for Complex 3-D Sensing", *IEEE/MTS Oceans 2001 Conference*; Honolulu, HI; Nov 2001; B. Hobson, B. Schulz, J. Janet, R. Moody, C. Pell, and H. Pinnix.
- "MicroAUVs I: Platform Design and Multi-Agent System Deployment", *Unmanned Untethered Submersible Technology (UUST)*; August 2001; Durham, NH; B. Schulz, B. Hobson, J. Janét, M. Kemp, R. Moody, C. Pell, H. Pinnix, J. Pollard, and H. Crenshaw.
- "Assessing the Performance of Oscillating Fin Thruster Vehicles", *Unmanned Untethered Submersible Technology (UUST)*; August 2001; Durham, NH; M. Kemp, B. Hobson, J. Janét, C. Pell, and E. Tytell.
- "Using Control Networks to Control Multiple Autonomous Mobile Robots: Biped, a Hexapod Colony, and a Complex Autonomous Mobile Robot", *IEEE Int'l Conf. on Robotics & Automation*; Detroit, MI; May 1998; J. Janet, B. Wiseman, R. Michelli, S. Scoggins, and A. Walker.
- "Autonomous Mobile Robot Global Self-Localization Using Kohonen and Region-Feature Neural Networks", *Jnl of Robotic Systems*; Vol. 14, No.4, 1997; J. Janet, R. Gutierrez, T. Chase, M. White, J. Sutton.
- "Combining Self-Organizing Geometric Certainty Maps with the Unscented Kalman Filter", Proc. of *IEEE Int'l Conf. on Robotics & Automation*; Leuven, Belgium; May 1998; J. Janét, J. Brickley, M. Kay, M. White, and J. Sutton.
- "Modeling of Sonar Sensors for Localization of Autonomous Mobile Robots", *IEEE Transactions on Industrial Electronics*; October 1998; R. Gutierrez, J. Janet, and R. Luo.
- "Autonomous Mobile Robot Global Motion Planning and Geometric Beacon Collection Using Traversability Vectors", *IEEE Trans on Robotics & Automation*; Vol.13, No.1, 1997, Pages:132–140; J. Janét, M. Kay, and R. Luo.

Skills Brief

- *Executive Leadership.* Provided fiscal, strategic, IP and operational leadership in application and development of heavily engineered systems for software, robotics and automation, medical, pharmacy, maritime, aviation, government, military, law enforcement, security, entertainment, hospitality, analytics, pattern analysis, and energy markets. Demonstrated ability to develop and implement business plans, integrate emerging technologies, raise capital, be an effective change agent, and transition product and client service concepts to commercial viability. Effective collaborator with companies, academic institutions, military, government and foreign entities. Experienced with legal aspects of launch, operations, equity, M&A, intellectual property & litigation. Successful manager of sales, marketing and finance including, ROI tool development, market research, prospecting, sales presentations, competitive analysis, brand development, multi-media advertising, contract negotiation, deal closure, A/P and A/R.
- *Board Member*. Effective strategic contributor and communicator on behalf of corporations (Delta Five, RxMedic, Panacea Biomatix, Lealear, and VortexHC) and an academic institution (NCSU IMSEI).
- *Engineering and Product Development.* Demonstrated ability to develop and deploy hardware and software products, including automated retrieval systems, fixed-base robots, medical systems, mobile robots, autonomous and remote-control unmanned ground robots, wall-climbing robots, hull inspection & cleaning

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robots, nuclear vessel inspection robots, autonomous underwater vehicles, non-destructive inspection robots, retail automation, and mine neutralization robots.

Additional

- **Security Clearance.** Personal clearance level – TOP SECRET & SCI. Facilities Security Officer (FSO) for Vortex HC. Coordinated processing of SECRET level Facility Clearances (FCL) and Personnel Clearances (PCL).
- **Institute of Electrical & Electronic Engineers (IEEE):** Robotics, Controls & Pattern Analysis.
- **Autonomous Unmanned Vehicle Systems International (AUVSI)**
- **American Society for Engineering Education (ASEE)**
- **American Society of Mechanical Engineers (ASME)**
- **PADI SCUBA:** Professional diver for underwater mobile robots, hull inspection, underwater video, counter-mine, ASW, etc.
- **Commercial Driver's License:** Class-A CDL, base registrations in North Carolina (and Virginia).
- **USPA Skydiving:** (1991 – 1997) USPA Jumpmaster certification in 1996. D-license with 400 jumps including instruction, tandem master training support, demonstrations, accuracy, and freefall relative work (RW). National collegiate RW championship team in 1994 (Richmond, IN). Carolina Sky Sports Accuracy Champion in 1993 (Louisburg, NC).
- **Pyrotechnician:** Class-A/B levels.
- **Master Mason:** Foundation of ~20 years of construction experience, primarily with ornamental stone, brick, and concrete. Experience initially gained as a youth within family-owned and operated business (Dogwood Quarries) in DC-metropolitan area; summers and school breaks from 1981 until 1997. Since 1998, all work has been *pro bono* including for Habitat for Humanity.

Computer Tools

Proficient: SalesForce, PowerPoint, Excel, Word, Project, MATLAB
Prior experience: Epicor ERP, QuickBooks, AutoCAD, SolidWorks, OrCAD, LabView, C/C++, Assembly

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