UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HESAI TECHNOLOGY CO., LTD.
Petitioner

v.

OUSTER, INC.
Patent Owner

U.S. Patent No. 11,287,515

EXHIBIT 1003 DECLARATION OF DR. MICHAEL LEBBY, PH.D.

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EXHIBIT LIST

No.	Short Name	Exhibit
1001	‘515 Patent	U.S. Patent No. 11,287,515 to Pacala *et al.*
1002	‘515 Prosecution History	Prosecution history for U.S. Patent No. 11,287,515
1003	Lebby Declaration	Expert Declaration of Dr. Michael Lebby
1004	Pacala	U.S. Patent Pub. No. 2014/0211194 to Pacala *et al*.
1005	Johnson	U.S. Patent No. 10,790,077 to Johnson
1006	Pardhan	U.S. Patent No. 10,749,308 to Pardhan *et al.*
1007	Zhang	Certified Translation of WO2018/201567 to Zhang *et al*. (WO2018201567A1_EN)
1008	Cai	Certified Translation of CN205027903U to Cai *et al*. (CN205027903U_EN)
1009	Hall	U.S. Patent No. 11,723,762 to Hall *et al*.
1010	Spector	U.S. Patent No. 10,473,766 to Spector *et al*.
1011	Droz	U.S. Patent No. 10,605,984 to Droz *et al.*
1012	Yan	U.S. Patent Pub. No. 2018/0003823 to Yan
1013	Pacala-2017	U.S. Patent Pub. No. 2017/0289524 to Pacala *et al*.
1014	Pennecot	U.S. Patent No. 9,651,658 to Pennecot *et al.*
1015	Verghese	U.S. Patent No. 10,845,470 to Verghese *et al.*
1016	Shah	U.S. Patent Pub. No. 2010/0030380 to Shah et al.

No.	Short Name	Exhibit
1017	ITC Complaint	Complaint in ITC Inv. No. 337-TA-1363
1018	Delaware Complaint	Complaint in *Ouster, Inc. v. Hesai Group et al*, No. 23-cv-00406 (D. Del.)
1019	Stay & Termination Order	(Part A) Order Granting Stay in *Ouster, Inc. v. Hesai Group et al.*, No. 23-cv-00406 (D. Del.) (Part B) ITC Inv. No. 337-TA-1363, EDIS Document Details re: Granting Motion for Termination
1020	Staff's Proposed Constructions	Commission Investigative Staff's Initial Proposed Constructions of Disputed Claim Terms (6-28-2023)
1021	Ouster's Proposed Constructions	Ouster's Initial Proposed Constructions of Disputed Claim Terms (6-28-2023)
1022	Hesai's Proposed Constructions	Hesai's Initial Proposed Constructions of Disputed Claim Terms (6-28-2023)
1023	NIST	*Performance Analysis of Next-Generation LADAR for Manufacturing, Construction, and Mobility*, National Institute of Standards and Technology (2004)
1024	Hipp	U.S. Patent No. 6,747,747 to Hipp
1025	DGC	*Report to Congress: DARPA Prize Authority* (2006)
1026	Team DAD	Hall *et al.*, *Team DAD Technical Paper*, DARPA Grand Challenge (2005)
1027	Hall-558	U.S. Patent No. 7,969,558 to Hall
1028	William	U.S. Patent No. 9,935,514 to William *et al.*

No.	Short Name	Exhibit
1029	Droz-649	U.S. Patent No. 9,059,649 to Droz *et al.*
1030	Kim	Sang-Hoon Kim, Electric Motor Control, 2017
1031	Tong	Mechanical Design of Electric Motors, 2014
1032	Gieras	Axial Flux Permanent Magnet Brushless Machines
1033	Bearing Units Manual	https://www.ntn-snr.com/sites/default/files/2017-03/ntn_bearing_units_en.pdf
1034	Johansen	U.S. Patent No. 11,374,458 to Johansen
1035	Phaneuf	U.S. Patent No. 2,818,518 to Phaneuf *et al.*
1036	Hunter	U.S. Publication No. 2016/0380523 to Hunter *et al.*
1037	Campisi	U.S. Patent No. 4,627,157 to Campisi *et al.*
1038	Poag	U.S. Patent No. 6,324,745 to Poag *et al.*
1039	Bockenstedt	U.S. Patent No. 7,946,986 to Bockenstedt *et al.*
1040	YMS PCB	Single-Layer vs. Multilayer PCBs, available at https://www.ymspcb.com/news/single-layer-vs-multilayer-pcbs-how-do-they-differ
1041	Hayner	U.S. Patent No. 3,375,386 to P.F. Hayner *et al.*
1042	Ricci	U.S. Patent No. 10,141,822 to Ricci *et al.*
1043	Nubling	U.S. Patent No. 9,606,230 to Nubling
1044	Ouster Priority Date Disclosure	Ouster's Notice of Patent Priority Dates
1045	Karplus	U.S. Patent No. 10,530,209 to Karplus *et al.*

No.	Short Name	Exhibit
1046	Pacala-2017 Provisional	Provisional Application No. 62/232,222
1047	Zhang	WO2018201567A1 to Zhang *et al*.
1048	Cai	CN205027903U to Cai *et al.*

I, Michael Lebby, declare as follows:

I. INTRODUCTION

1. I have been retained by Petitioner, Hesai Technology Co., Ltd. ("Hesai"), to provide my opinions concerning the invalidity of claims in U.S. Patent No. 11,287,515 ("the '515 Patent").

2. I am being compensated for my time in connection to this matter at the rate of $450/hr. My compensation is not in any way contingent upon the opinions that I express or the outcome of this proceeding or any related litigation. I have no financial or personal interest in the outcome of this proceeding or any related litigation.

3. In forming the opinions expressed in this declaration, I relied upon my education and experience in the relevant field of the art, and I considered the viewpoint of a person having ordinary skill in the relevant field of the art ("POSITA") as of the priority date of the '515 Patent on December 4, 2018.

II. QUALIFICATION

4. Over the course of my 45-year career I have worked in nearly every aspect of optoelectronics and optical technology. I have also worked on electronics, motors, sensors, and other technologies that combine photonics with electronics.

5. I have also served as an expert witness on LiDAR technology, including on cases involving parties that are the assignees of the prior art I discuss in this

declaration, for example: [1] *Quanergy Systems, Inc. v. Velodyne LiDAR, Inc.* (16-cv-05251; N.D. Ca.), [2] *Waymo LLC v. Uber Technologies, Inc.* (3:17-cv-00939).

6. Over the course of my career, I have also given numerous keynote and invited presentations, speeches, panels, and talks at workshops and conferences, including on LiDAR. As just one example, I was an invited panelist at the 6th Photonic Integrated Circuits International Conference for the panel entitled "PICs for LIDAR."

7. I received a Bachelor of Electrical Engineering degree in 1984, a Master of Business Administration in 1985, and a Doctorate degree in 1987, all from University of Bradford in the United Kingdom. My Ph.D. thesis involved the design and fabrication of both optoelectronic and electronic semiconductor devices, and their associated characterization. In 2004, I was awarded a Doctor of Engineering degree from University of Bradford for my technical contributions to the field, with citation to "Technical Contributions to Optoelectronics."

8. From 1985-1989, I also worked at AT&T's Bell Labs and focused in the fields of photonics and electronics.

9. After I completed my Ph.D. at the University of Bradford and my work at Bell Labs, I became a Research and Development Manager ("R&D Manager") in the photonics division of Motorola's Corporate R&D Labs ("Motorola") from 1989 to 1998. My responsibilities at Motorola included research and development of laser

devices, optical lenses, and optical waveguides as well as the packaging and reliability of mobile product prototypes. These prototypes included moving parts with motors. While at Motorola, I was the inventor or co-inventor of over 150 utility patents. In 1998, I received a special award from the Chairman of Motorola for exemplary patent accomplishments. At that time, I had the highest number of issued utility patents in the history of Motorola.

10. From 2005 to 2010, I became the Executive Director, President, and CEO of the Optoelectronic Industry Development Association (OIDA), a trade association that represented photonics manufacturers in various fields, including sensing, aerospace, automotive/motor vehicles, *etc*. I was responsible for organizing technical conferences, workshops and forecasts using industry roadmaps that featured automotive photonic technologies, wavelength division multiplexing, optical sensors, *etc*.

11. In 2010, I became the General Manager and CTO of Translucent, Inc., a start-up company that developed and manufactured silicon and rare earth oxide-based epitaxial semiconductor wafers.

12. I joined Glyndŵr University from 2013 to 2015 as a Professor of Optoelectronics, where I focused on the design, simulation and testing of high speed, low power photonic integrated circuits, optoelectronic integrated circuits, laser diodes, and optics, among other things.

13. I hold over 450 issued international patents in photonics and electronics, that have been derived from over 230 issued U.S. utility patents, mostly in the field of optoelectronics, photonics, electronics, and semiconductors. I have been cited by the USPTO to be in the most prolific seventy-five inventors in the United States from 1988 to 1997.

14. I have authored approximately sixty-five (65) publications, including technical articles, books, and book chapters, and have been a speaker at various technical and business-related conferences. Over the past decade, I have also been a project reviewer and technical expert for the European Commission on numerous occasions.

15. I am currently Chairman, CEO, and Director of the Board of Directors for Lightwave Logic. In addition, I am currently the CEO and CTO at GenusTechnik Inc., which provides consulting services in the areas of photonics and optoelectronics.

16. A more detailed description of my education, as well as my training and experience in the relevant technology, is included in my *curriculum vitae* filed herewith as **Appendix A**.

III. LEGAL PRINCIPLES AND UNDERSTANDINGS

17. In forming my opinions and considering the subject matter of the '515 Patent and its claims in light of the prior art, I am relying on certain legal principles

that counsel in this case explained to me. My understanding of these concepts is summarized below.

18. I understand that the claims define the invention. I also understand that an unpatentability analysis is a two-step process. First, the claims of the patent are construed to determine their meaning and scope. Second, after the claims are construed, the content of the prior art is compared to the construed claims.

19. I understand that a claimed invention is only patentable when it is new, useful, and non-obvious in light of the "prior art." That is, the invention, as defined by the claims of the patent, must not be anticipated by or rendered obvious by the prior art.

A. Claim Construction

20. I understand that the United States Patent and Trademark Office interprets claim terms in an *inter partes* review proceeding under the "*Philips*" claim construction standard. I understand that under this standard, the meaning of claim terms is considered from the viewpoint of one of ordinary skill in the art at the time of the alleged invention. I have used the priority date of the '515 Patent, December 4, 2018, as the point in time for claim interpretation purposes. However, the interpretations that I provide below would have also been correct if the date of alleged invention was a year earlier.

B. Anticipation

21. I understand that a patent claim is invalid based on anticipation if a single prior art reference discloses all of the features of that claim, and does so in a way that enables one of ordinary skill in the art to make and use the invention. Each of the claim features may be expressly or inherently present in the prior art reference. I understand that if the prior art necessarily functions in accordance with, or includes a claim's feature, then that prior art inherently discloses that feature. I have relied on this understanding in expressing the opinions set forth below.

22. I understand that a prior art reference describes the claimed invention if it either expressly or inherently describes each and every feature set forth in the claim; i.e., in determining whether a single item of prior art anticipates a patent claim, one should take into consideration not only what is expressly disclosed in that item, but also what is inherently present as a natural result of the practice of the system or method disclosed in that item.

C. Obviousness

23. I understand that a patent may not be valid even though the invention is not identically disclosed or described in the prior art if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the art in the relevant subject matter at the time the invention was made.

24. To determine if a claim is obvious, the following factors should be considered: (1) the level of ordinary skill in the art at the time the invention was made; (2) the scope and content of the prior art; (3) the differences between the claimed invention and the prior art; and (4) secondary considerations, including evidence of commercial success, long-felt but unsolved need, unsuccessful attempts by others, copying of the claimed invention, unexpected and superior results, acceptance and praise by others, independent invention by others, and the like.

25. For example, I understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand that an obviousness analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim because a court can take account of the inferences and/or creative steps that a person of ordinary skill in the art would employ.

26. I understand that the obviousness determination of an invention turns on whether a hypothetical person with ordinary skill and full knowledge of all the pertinent prior art, when faced with the problem to which the claimed invention is addressed, would be led naturally to the solution adopted in the claimed invention or would naturally view that solution as an available alternative. Facts to be evaluated in this analysis include:

- The scope and contents of the prior art;

- Differences between the prior art and the claims at issue;
- The level of ordinary skill in the pertinent art; and
- Evidence of objective factors suggesting or negating obviousness.

27. I understand that the following rationales may be used to determine whether a piece of prior art can be combined with other prior art or with other information within the knowledge of one of ordinary skill in the art:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known techniques to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- "Obvious to try" - choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; or
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

28. I understand that when a work is available in one field of endeavor, design incentives and/or other market forces, for example, can prompt variations of it, either in the same field or a different one. Moreover, if a person of ordinary skill

can implement a predictable variation, I understand that that likely bars its patentability.

29. I understand that obviousness must be tested as of the time the invention was made. I understand that the test for obviousness is what the combined teachings of the prior art references would have suggested, disclosed, or taught to one of ordinary skill in the art. In particular, it is my understanding that a patent claim is invalid based upon obviousness if it does nothing more than combine familiar elements from one or more prior art references or products according to known methods to yield predictable results. For example, I understand that where a technique has been used to improve one device, and a person of ordinary skill in the art would have recognized that it would improve similar devices in the same way, using that technique is obvious. I understand that obviousness can be proved by showing that a combination of elements was obvious to try, i.e.: that it does no more than yield predictable results; implements a predictable variation; is no more than the predictable use of prior art elements according to their established functions; or when there is design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions. I have been further informed that when a patent claim simply arranges old elements with each element performing the same function it had been known to perform and yields results no more than one would expect from such an arrangement, the combination is obvious.

30. I understand that another factor to be considered is common sense. For example, I 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 will be able to fit the teachings of multiple patents together like pieces of a puzzle.

31. I understand that the Supreme Court articulated additional guidance for obviousness in its *KSR* decision. My understanding is that the Supreme Court said that technical people of ordinary skill look for guidance in other solutions to problems of a similar nature, and that the obviousness inquiry must track reality, and not legal fictions. I have relied on these understandings in expressing the opinions set forth below.

32. I understand that a new use of an old product or material cannot be claimed as a new product; the apparatus or system itself is old and cannot be patented. I further understand that, in general, merely discovering and claiming a new benefit to an old process cannot render the process newly patentable.

D. Secondary Consideration of Non-Obviousness

33. I understand that certain secondary considerations may be considered in evaluating obviousness in order to prevent hindsight bias. These secondary considerations include commercial success of products that practice the patent, long-felt need for the patented technology, failure by others to solve the problem

addressed by the patent, initial skepticism by others in the industry, industry recognition and praise of the patented products, and efforts by others to copy the patented technology.

34. I have been informed that these secondary considerations of non-obviousness must be balanced against the strength of the prima facie case of obviousness. Where the invention represents no more than the predictable use of prior art elements according to their established functions, secondary considerations are inadequate to establish non-obviousness.

35. I have also been informed that the patentee must establish a nexus between any secondary consideration factors and the claimed invention. Where a secondary consideration factor results from something other than what is both claimed and novel in the patent, there is no nexus to the merits of the claimed invention.

36. I have been informed that, for example, the nexus requirement as it applies to the evidence of commercial success requires that the patentee must show that the sales of a product that allegedly practices the claimed invention must be a direct result of the unique characteristics of the claimed invention, as opposed to other economic and commercial factors that are unrelated to the patented invention. I understand that this means if the commercial success is due to an element that existed in the prior art or that is not claimed by the patent, then no nexus exists.

37. I have been further informed that, for example, the nexus requirement as it applies to the long-felt need element must likewise be supported by evidence. Where the differences between the prior art and the claimed invention are minimal, it cannot be said that any long-felt need was met by the patented invention or that the patent solved any technological problems that were unaddressed by others.

38. I have been informed that evidence of industry praise must also show a nexus with the claimed invention, and that self-serving statements by the patentee regarding the merits of the claimed invention are generally not given weight.

IV. LEVEL OF ORDINARY SKILL IN THE ART

39. In my opinion, a person of ordinary skill in the art as of December 4, 2018 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. Less work experience may be compensated by a higher level of education or vice versa. The same level of skill would apply a year earlier.

40. The claims of the ’515 patent are directed at a rotor-stator structure that includes an integrated PCB motor for rotating a LiDAR device mounted on a rotor relative to a stator, as well as conventional electronics (*e.g.*, circuit boards, power

transformers and communication interfaces). POSITAs working on these types of devices typically hold undergraduate degrees in mechanical or electrical engineering. Further, two to three years of work experience with electro-mechanical and electro-optical devices would provide an engineer with more specialized focus on the mechanical and electrical technologies underlying motors, communication and power electronics, as well as the optics principles and devices (e.g., emitters, detectors, processing circuitry, *etc*.) underling LiDAR technologies.

41. I am well aware of the qualifications of such a skilled artisan. I have a Ph.D. in electrical and electronic engineering and a second doctorate (Doctor of Engineering) also in electronic engineering. By the time of the priority date of the '515 patent, I also had over 40 years of practical experience working on electrical and mechanical systems, optoelectronics, and optics, as detailed in my CV. This includes work on rotating motors, as well as utilizing lasers for time of flight, sensing, and photodetector research. I had also worked with, supervised, and hired engineers with the qualifications of a POSITA. Further, as explained in Section II, I have served as an expert witness on LiDAR technologies—including cases involving the very companies that are assigned the prior art at issue in this Declaration—and have also been a presenter and panelist at conferences discussing LiDAR technologies. Thus, I am familiar with the understanding and knowledge of POSITAs in the art as of 2018, and was at least as qualified as the POSITA that I

have identified above.

V. SUMMARY OF OPINIONS

42. I understand Hesai's Petition challenges claims 1-2, 4-9, 11-14, 16-17, 19-25 of the '515 Patent based on the grounds identified below. In my opinion, the challenged claims are invalid as obvious based on these grounds.

Ground	Claims	Description
1	1-2, 4-9, 11, 14, 16-17, 19	Obvious based on Pacala-Johnson-Pardhan-Zhang.
2	2, 4-6, 17	Obvious based on Pacala-Johnson-Pardhan-Zhang-Cai.
3	5-6	Obvious based on Pacala-Johnson-Pardhan-Zhang-Cai-Hall.
4	12, 20	Obvious based on Pacala-Johnson-Pardhan-Zhang-Spector.
5	13, 21	Obvious based on Pacala-Johnson-Pardhan-Zhang-Spector-Droz.
6	22-24	Obvious based on Pacala-Johnson-Pardhan-Zhang-Droz-Cai-Yan.
7	25	Obvious based on Pacala-Johnson-Pardhan-Zhang-Droz-Cai-Yan-Spector.
8	1, 2, 4-9, 11-14, 16-17, 19-21	Obvious based on Pacala-2017-Johnson-Pardhan- Zhang
9	22-25	Obvious based on Pacala-2017-Johnson-Pardhan-Zhang-Cai-Yan.

VI. TECHNOLOGY BACKGROUND

A. LiDAR and Time-of-Flight

43. The word LiDAR is derived from light detection and ranging and is similar to RADAR which is radio detection and ranging. There have been various approaches to use light to undergo detection and ranging, and there is a general consensus that the first concepts to apply this technique were made in the 1920s and 1930s using high intensity beams of light (otherwise known as searchlights) for

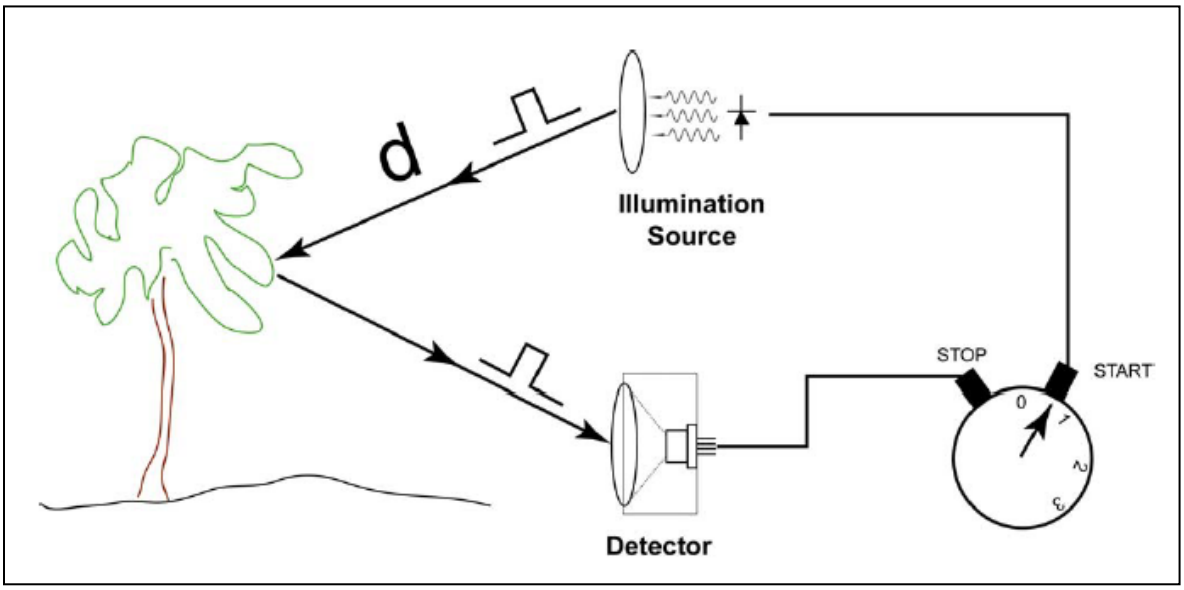
analysis of the atmosphere.

44. With the invention of the laser in the early 1960s, the invention of LiDAR in general has been given to Hughes Aircraft company who utilized lasers for a LiDAR detection and ranging system. While the term LiDAR is popular today, it does include another acronym called LADAR which represents laser based detection and ranging. The two terms are synonymous today.

45. The key components of a LiDAR system are the light source which is typically laser based and a sensor or photodetector. LiDAR systems also have electronic circuitry, optical components such as lenses, mirrors, focusing elements, as well as structures to hold the photonics (optoelectronics and photonics components) and electronics.

46. A LiDAR system will emit light in a beam to an object some distance from the LiDAR unit and capture the reflected signal via the photodetectors. As the LiDAR system is a detection and ranging system, the distance from the LiDAR system to an object that received the laser light (typically through a pulse of light) can be measured by dividing the time interval between emission of the light and the detection of light by the speed of light. This is then halved to account for the a round trip of light that is reflected off a distant object. For example, if the time it takes a light pulse to leave the LiDAR system, be reflected off an object and detected by the LiDAR system is 100nSec, then, then the distance can be calculated to be

approximately (1 x 10^{-7} s / 2.99 x 10^{8} m/s) / 2 = 15 meters. This measurement principle which is commonly known in the industry, is called "time-of-flight" (or "ToF"), can be seen in the figure below:

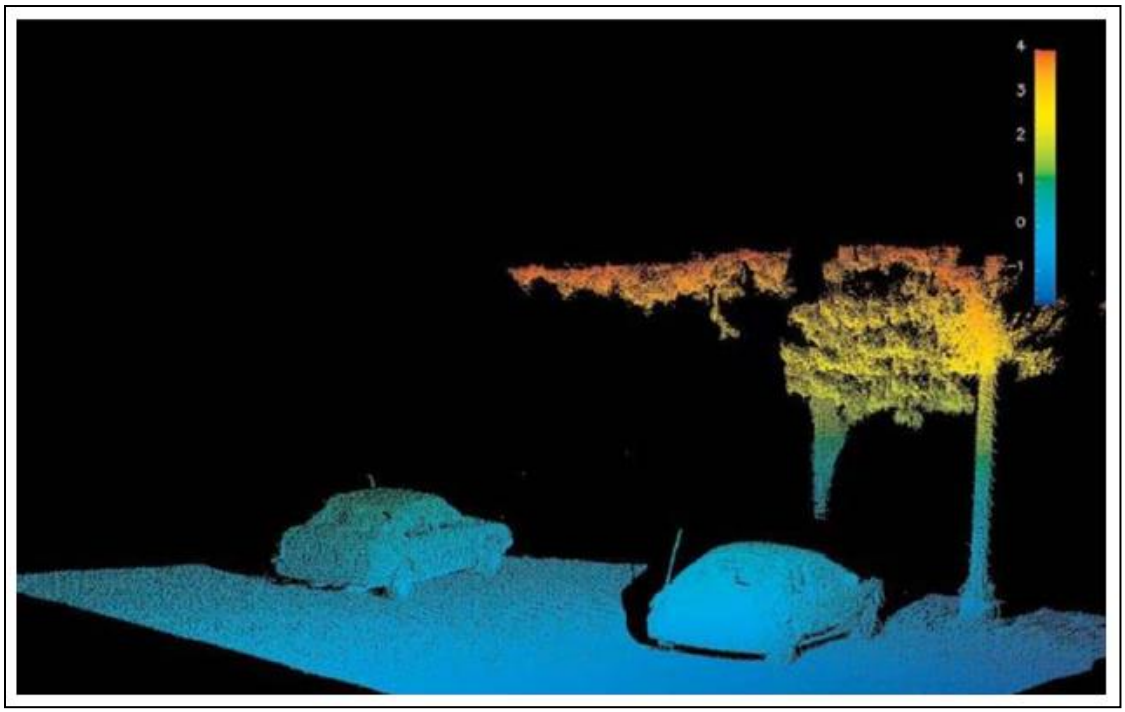


EX1023 at 2.3.

47. Early LiDAR systems utilized a single laser and were designed for 1D or single dimensional measurements of a target. Two dimensional (2D) LiDAR systems followed where target measurements could be achieved in a plane or axis.

48. As the technology advanced in the 1980s and 1990s, engineers saw that the number of targets (or object points) could be increased, which led to a more detailed mapping of the target environment that surrounded the LiDAR system. This meant that the LiDAR system needed to be able to scan or move the target field. Various solutions were proposed that included moving or rotating the LiDAR device to scan a wider and broader area. U.S. Patent No. 6,747,747 ("Hipp"), for example,

observed that 3D point cloud coverage could be improved by rotating the light source emitters and light photodetectors through a broad horizontal field-of-view, such as a 360-degree sweep. EX1024, 4:1-11. These developments led to numerous commercial sensors capable of generating three-dimensional point clouds over a larger field-of-view during the first decade of the new century. An early example point cloud is illustrated below:



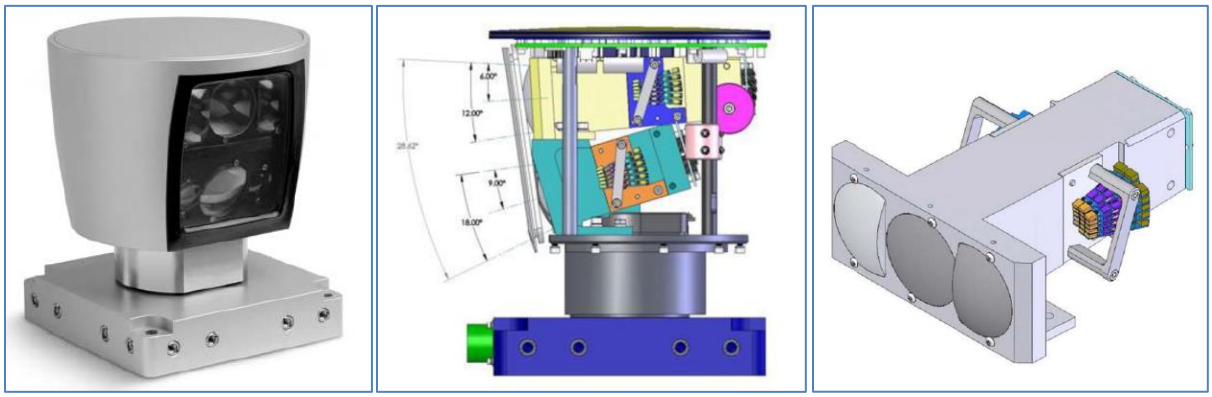
EX1023 at Fig. 6.3.

B. LiDAR for Autonomous Vehicle Applications

49. In the early 2000s, interest in LiDAR systems increased, and a well-known defense agency called DARPA initiated projects to advance LiDAR systems in general. The well-documented 2005 DARPA Grand Challenge focused on

advancing both the electronics, photonics, as well as mechanical technology towards autonomous navigation in land-based military vehicles. EX1025. The 2005 event was held along a 132-mile offroad course near the Nevada-California state line. *Id*. Teams from private industry and academia designed and qualified custom vehicles equipped with LiDAR systems to compete in the event, with a team from Stanford University ultimately taking first prize.

50. One of the LiDAR system entries was "Team DAD," which operated out of the facilities of Velodyne Acoustics. EX1026, 1-2. The Team DAD vehicle was a 2003 Toyota Tundra, with a rotating LiDAR system mounted on roof of the vehicle. *Id*., 8-9. This LiDAR system included sixty-four laser source-detector pairs on a rotating mount attached to a fixed base. *Id*. The rotational mount allowed the device to achieve a 360-degree horizontal field-of-view, and angular spacing of the laser source-detector pairs allowed it to achieve an approximate 20-degree vertical field-of-view. *Id*. This LiDAR system produced a "very high-density profile map of the surrounding environment," which was supported by software coding to allow for autonomous navigation decisions. *Id*. Velodyne commercialized its first LiDAR system shortly thereafter with a product called HDL-64E, which is shown below:

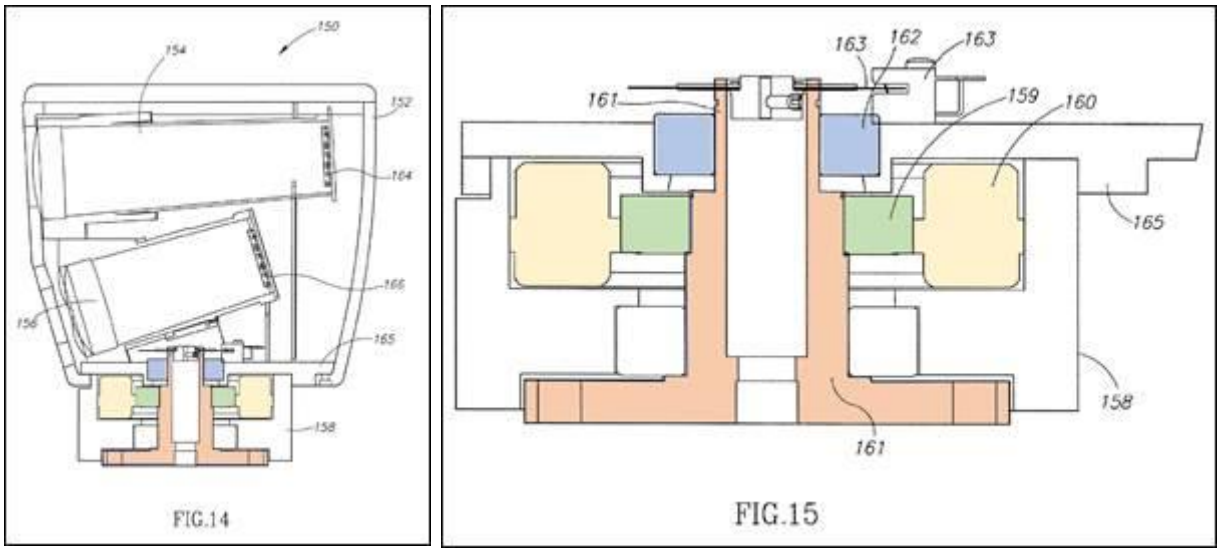


C. Rotary Components of LiDAR Devices

51. LiDAR systems have been used in vehicle operations for broad 360-degree object targeting. For example, as noted above, an early developer of LiDAR systems was a company called Velodyne, which demonstrated a rotating LiDAR system for autonomous vehicles in 2005. This system was later patented in Hall-558. EX1027. One of the features of a rotating LiDAR system is its rotation speed. Higher rotation speeds allow the LiDAR system to collect a greater number of points per unit area, resulting in the creation of denser point clouds. For instance, Hall-558 teaches that its LiDAR system may rotate "at a rate of up to 200Hz," thereby collecting "1 million time of flight (TOF) distance points per second" and "providing a high point cloud refresh rate." *Id*., at 4:5-18.

52. LiDAR systems typically employ a rotational mount and electric motor that rotates the housing unit about a stationary base and is designed to allow data communication from the rotating elements to the stationary base. For example, Hall-558's LiDAR system describes a DC motor that utilizes brushes, mounted on a

rotating platform and driven by an actuator. In this LiDAR system, the DC motor rotates the optical imaging receive module about a vertical axis through 360-degrees. *Id*., 5:39-40 ("A simple DC motor controller driving a high reliability brushed motor controls the rotation of the emitter/detectors."), 8:30-32. The DC motor components are shown in Figures 14 and 15, which include a rotary coupling 161, bearing 162, rotor 159 and stator 160:



Id., Figs. 14-15, 6:50-63.[1]

53. It can be seen that the LiDAR system, as taught by Hall, utilized a brushed DC motor design. LiDAR systems that emerged after Hall, including those from Waymo LLC, utilized brushless DC motors design ("BLDC motors")—including brushless printed circuit board motors that integrated the rotor and stator

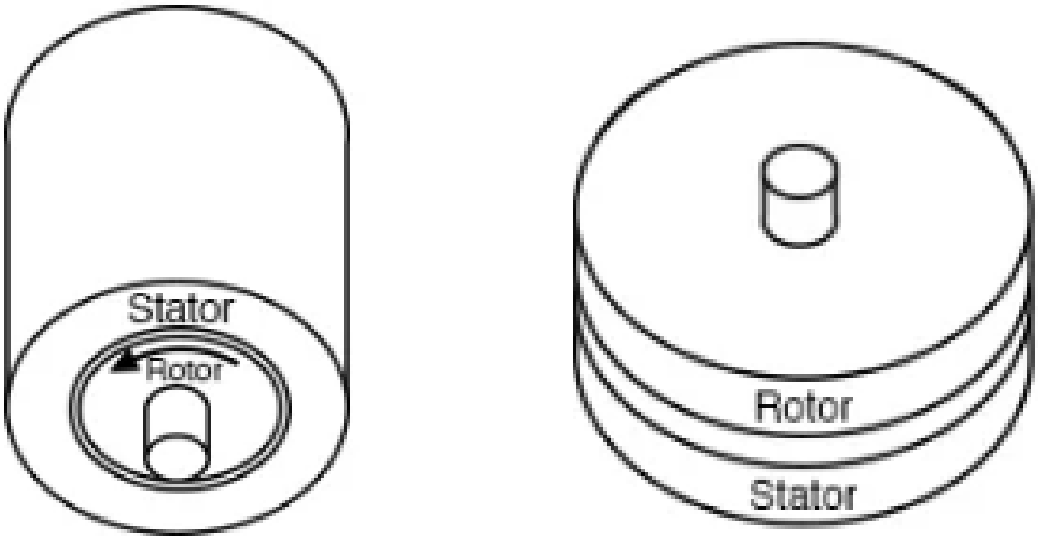
[1] Unless otherwise noted, colored text or highlights in patent figures are annotations that have been added.

components into circuity boar. *See, e.g.*, EX1028, 1:24-28 ("In one example, a printed circuit board (PCB) of a multi-phase brushless motor is provided."); EX1029, 3:7-11 ("the motor may be a three-phase brushless motor with a rotating permanent magnet (rotor) and a stationary armature (stator) having a plurality of conductive coils spaced substantially equally apart.").

D. Brushless DC Motors

54. BLDC motors, in general, and especially for LiDAR systems, appear in many forms and mechanical designs. Two of the most common styles of construction for a BLDC motor are [1] "radial field (or flux)" and [2] "axial-field (or flux)." EX1030, 394; EX1031, 55-56; EX1032, 1. In a radial-flux motor, the magnetic field travels in the radial direction. *Id*. This type of motor is typically found as a cylindrical design and format. *Id*. In an axial-flux motor, the field travels in the axial direction. *Id*. This type of motor typically has multiple disk- or flat-shaped rotors and stators that are attached together using a shaft that defines the axis of rotation. *Id*. It is sometimes referred to as a "pancake" motor. *Id*.; *see also* EX1001, 30:5-10 ("The motor can have a 'pancake' or 'axial' design having a planar rotor assembly on a rotor board that opposes a planar stator assembly on an opposing stator board."). Both designs are well-understood and have been used for many decades across various applications. *See, e.g.*, EX1041 (patent entitled "Printed Circuit Motor," filed on "Mar. 26, 1968").

55. There were "many topologies of AF [axial-flux] machines" and radial-flux machines known in the art by the time of the '515 Patent. EX1030, 646. The figure below illustrates a typical radial-flux motor on the left, while a typical axial-flux motor is shown on the right.



EX1031, 394; EX1032, 18. The '515 Patent describes embodiments that use the typical "'axial' design" that is shown on the top right, with a pancake shaped rotor that rotates about a shaft relative to a fixed, pancake shaped stator. EX1001, 30:5-67.

56. As can be seen in the images above, there are two key elements or components of a BLDC motor: the rotor and stator. EX1031, 3. The rotor is the part of the motor that rotates and includes permanent magnets that are arranged to form magnetic poles that alternate polarity between north and south. EX1031, 394; EX1032, 107-109. The stator is the stationary part of the motor and carries the

windings of the motor. EX1031, 3; EX1032, 107-111.

57. In a BLDC design, the rotor's magnets and stator windings provide the basis for the rotation of the motor. These motor designs can be "categorized according to their number of stator windings" as "single-phase, two-phase, three-phase, and multi-phase." EX1031, 393. Generally, the operating principle of the BLDC motor is to change the phase windings, which are excited according to the position. *Id*., 394-395. Activating a current through the windings creates a magnetic field which will cause a movement in the rotor. *Id.* The magnetic field polarity depends on the current direction, and electronic circuitry can be used to operate and set the motor's speed and direction by providing electrical signals and electrical power to the coils. *Id*.

58. For example, the figure below shows a simple generic drive system for a three-phase BLDC motor. This system includes three-phase windings (labeled a, b and c) and three "Hall sensors" that provide the controller with information about the position of the rotor (labeled H1, H2 and H3). *Id*.

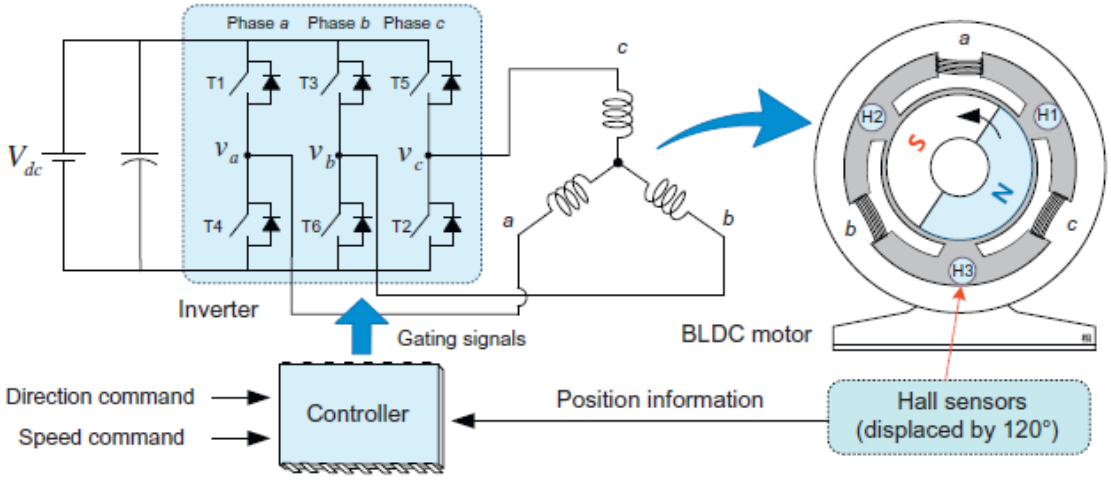


FIGURE 10.6

BLDC motor drive system.

Id. A controller can set the direction and speed of the motor by providing a drive signal to the phase windings. *Id*., 396-397.

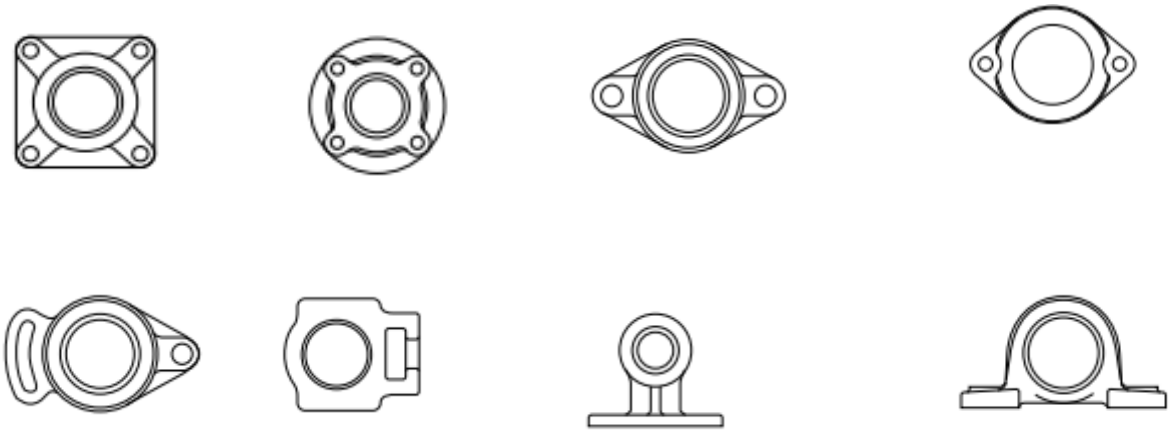
59. BLDC motor designs have distinct advantages over brushed motors, including enhanced reliability and lifetime because they replace mechanical commutation with electronic commutation. *Id*., 389. The electronic commutation provides improved and more efficient current switching, and generally results in increased speed, torque, efficiency, and a longer lifetime. *Id*. These advantages have helped BLDCs to become more popular in industry and they have been used widely in a number of applications that include LiDAR system for autonomous applications.

E. Bearing Assemblies

60. Bearing assemblies are well-known to a POSITA and historically have been around in various industries for over 100 years. In general, an electric motor

typically utilizes a bearing assembly to support rotating mechanical parts that normally include shafts. EX1031, 309 ("The purpose of bearings in electric motors is to support and locate the rotating rotor in both radial and axial directions…"). Bearing assemblies in general are used in a wide variety of applications in addition to motors, from machinery, to vehicles, to industrial equipment.

61. Bearing assemblies in general can come in many different mechanical and structural configurations. For example, the images below show several bearing assembly designs that were commercially available by the priority date of the '515 Patent:



EX1033. These bearing assemblies were used in a variety of applications, including motors, for supporting a rotating shaft. They include a central hole in which the shaft of the motor is inserted and arms extending outwards from the shaft for attachment to a platform, *e.g.*, a rotor platform. *Id*.

62. A POSITA at the time understood that the designs above and other

similar designs, could be interchangeably used for attachment to a rotating platform of an electric motor. For instance, where the attachment surface is parallel to the shaft, a design similar to that shown on the bottom right may be used. In contrast, when an attachment surface is perpendicular to the shaft a design similar to those shown in the top row may be used. *See also* EX1042, Fig. 8 (illustrating an axial-flux motor with a support structure 704 comprising four arms extending outwards from a central hole in which the shaft is inserted), 6:40-56. Moreover, a POSITA would have understood that "[i]n normal motor operation, bearings must be held in their positions firmly," such that bearing housings having attachment arms are desirable to minimize vibrations and movements that may damage the motor. EX1031, 329-331 ("Section 6.2.5 Prevention of Bearing Axial Movement").

F. Alignment Posts

63. By the priority date of the '515 Patent, utilizing alignment posts, which can also be termed locating posts, for the purpose of aligning two or more components was not only a well-known technique stretching back to the early 1900s, but popular in the industry. Generally, the practical use of alignment posts in the manufacturing of electric motors dates back many decades and is well-known to a POSITA. For example, U.S. Patent No. 2,818,518, entitled "Electric Motor and Method of Manufacture Therefor, which was filed on March 17, 1954, teaches the use of "a pair of alignment posts 6" that are used "to facilitate proper alignment" of

motor components. EX1035.

64. By the priority date of the '515 Patent, alignment posts were commonly used in various industrial and commercial applications, including electric motors, to ensure accurate positioning of the components being assembled in volume and to avoid shifting or physical movement of the parts during assembly operations and operation in general. *See, e.g.,* EX1036, [0040]-[0042] ("Sidewall 222a also includes a ring of six alignment posts 227 located nearer to the outer permitter of the sidewall…The alignment posts on the sidewall of each coil assures that holes through each coil are aligned with corresponding holes in all of the rest of the coils"); 1037, 3:5-19 ("alignment posts 16 are used in conjunction with a circuit board positioned immediately above the support panel 12 in order to ensure proper alignment therebetween."); EX1038, 10:37-58 ("The cooperation of the rotor tab 300, the end-shield assembly locating notch 230, the locating posts 250, 260, and the sensor assembly mounting holes 500, 510 ensure that the Hall devices 530 are oriented in a known position with respect to the stator assembly 140."); EX1039, 38:43-46 ("an alignment post 640 is positioned on one location of the top plate 630. The alignment post 640 permits an installer to properly align the lower compartment 600 with an upper compartment of the therapy head during installation.").

VII. OVERVIEW OF THE '515 PATENT

65. I have reviewed the '515 Patent. The patent is titled "Rotating Compact

Light Ranging System Comprising A Stator Driver Circuit Imparting An Electromagnetic Force On A Rotor Assembly" and names Angus Pacala, Mark Frichtl, Marvin Shu, Eric Younge. EX1001. It was filed on May 18, 2021, as a continuation of U.S. Application No. 16/209,875, filed on December 4, 2018. *Id*. The patent issued on March 29, 2022, and states it was assigned to Ouster, Inc. *Id*.

A. Priority

66. I have been informed that the priority date for the '515 Patent is December 4, 2018.

B. Specification

67. The '515 Patent is directed to a structure for rotating a LiDAR unit about a fixed base. EX1001, Abstract. Figure 2A shows the basic structure of the device 200, including a LiDAR unit 210, housing 220, first circuit board assembly 222, rotational coupler 224, and base circuit board assembly 226:

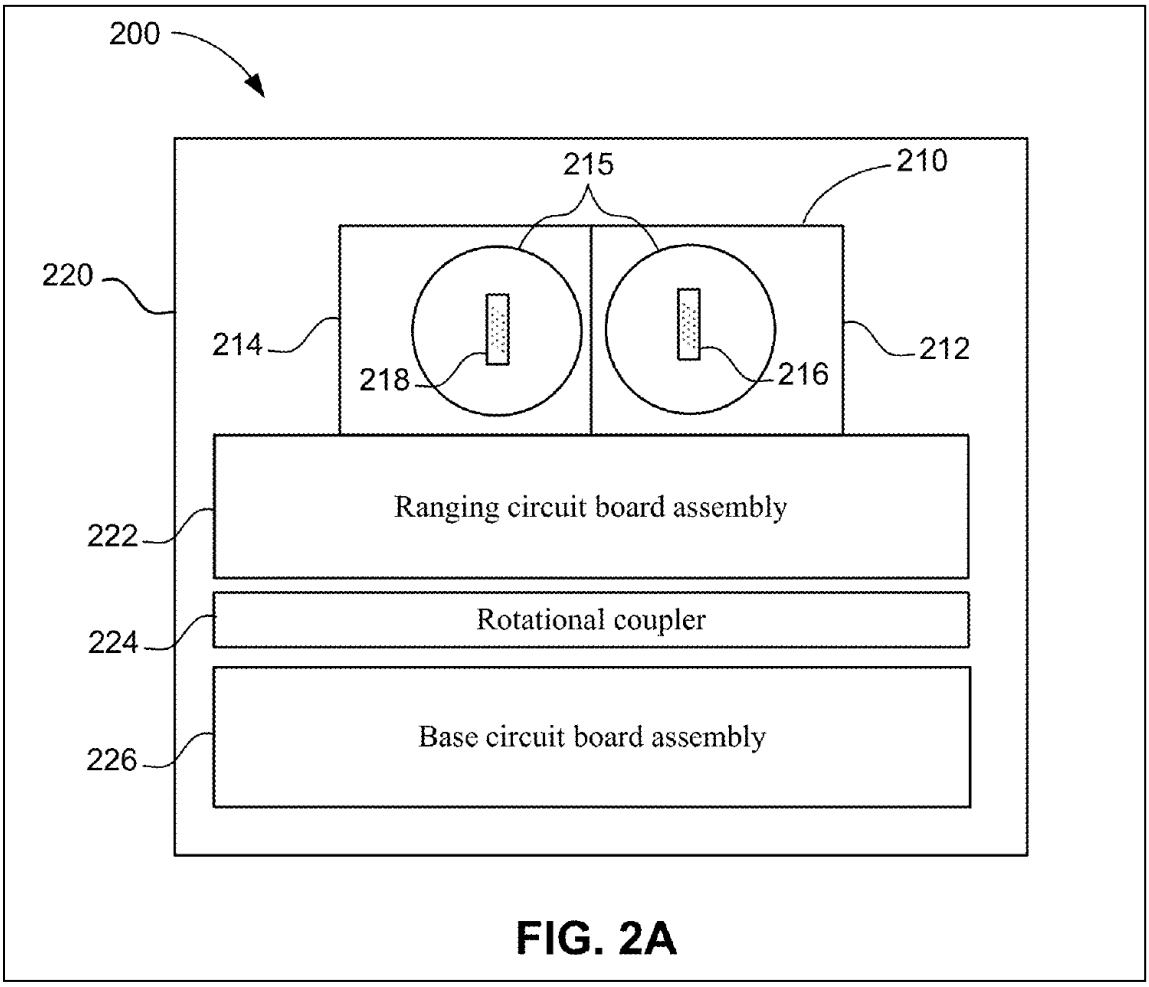
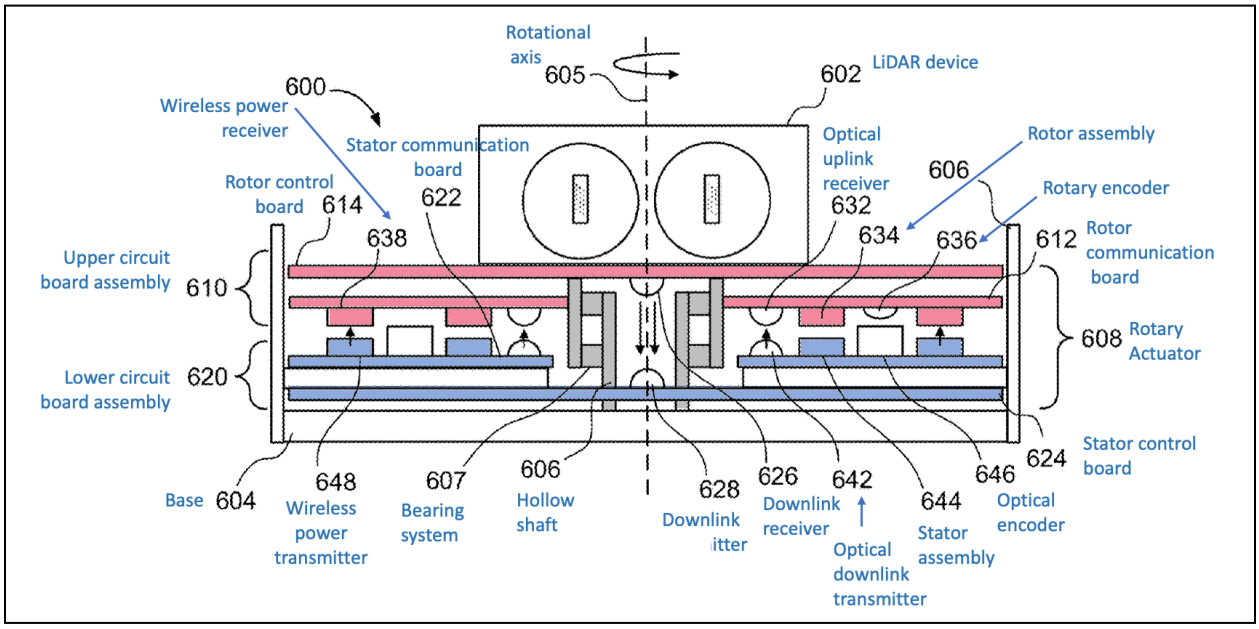


FIG. 2A

Id., Fig. 2A. The "ranging circuit board assembly 222" is also referred to in the '515 Patent as a "turret circuit board assembly," and the "base circuit board assembly 226" is also referred to in the '515 Patent as a "stator assembly." *Id.*, 16:12-33; *see also id.* at 10:35-50. The '515 Patent also explains that the "rotational coupler 224" may be "implemented in a number of different ways," for example a "shaft and bearing structure." *Id.*

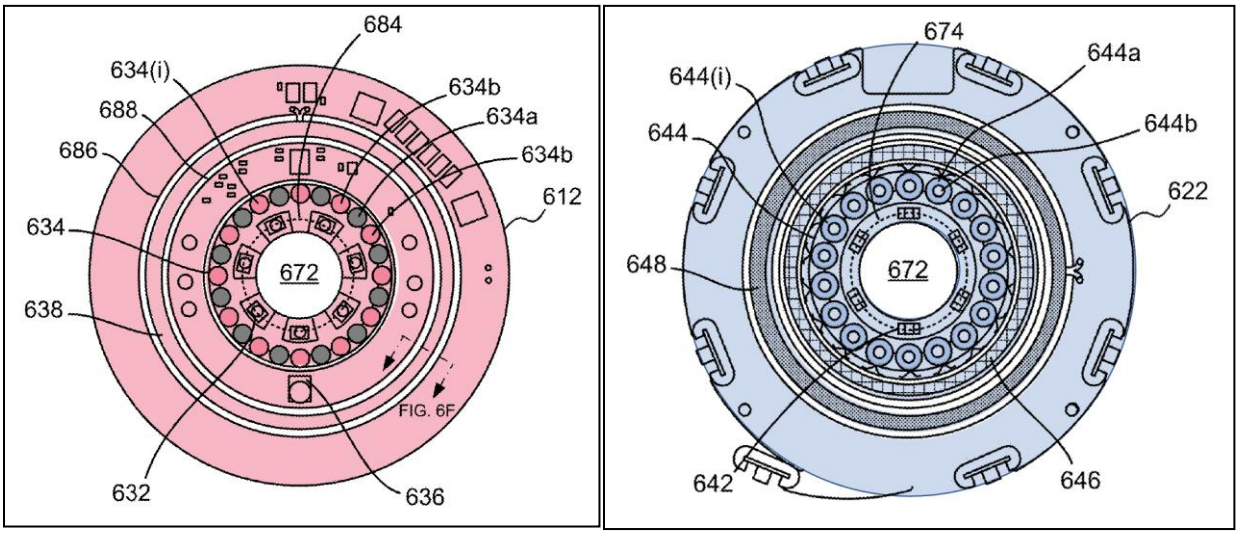
68. Figures 6A-C provide additional details about the rotational features of the disclosed embodiments. *Id.*, 26:3-18. Figure 6A is reproduced below, labeled

with descriptions from the specification and annotated to show principle features of the rotor assembly (red), stator assembly (blue), and shaft / bearing assembly (grey):



Id., Fig. 6A.

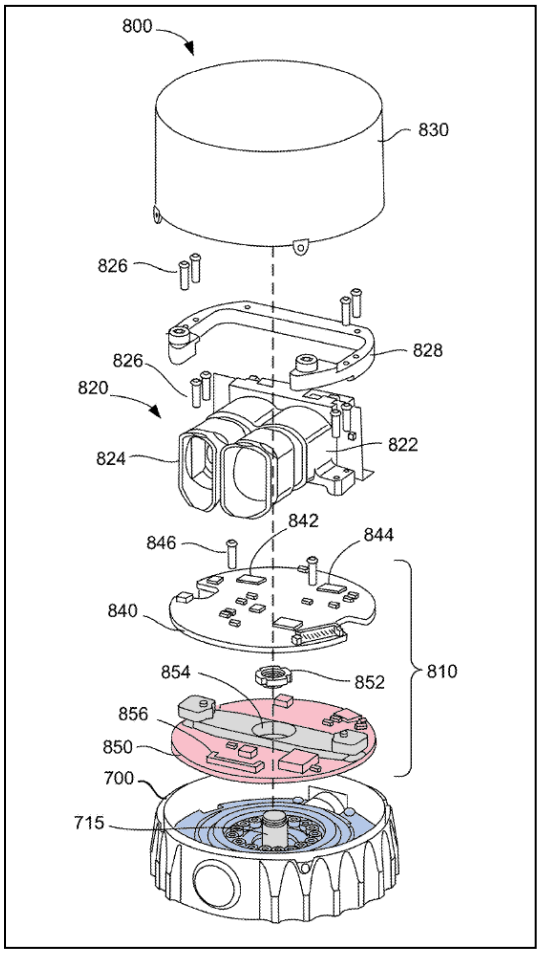
69. The '515 Patent states that an "electric rotary motor can be integrated directly onto the circuit boards" and includes embodiments in which "the motor can have a 'pancake' or 'axial' design having a planar rotor assembly on a rotor board that opposes a planar stator assembly on an opposing stator board." *Id.*, 30:5-67. Details of the rotor and stator assemblies are illustrated in Figures 6D-E. Figure 6E illustrates the rotor communication board 612 and rotor elements 634, and Figure 6D illustrates the stator communication board 622 and stator elements 644:



Id., Figs. 6E, 6D, 30:15-67.

70. The individual stator elements 644 "can include a solenoid coil 644a wound around a core 644b of magnetic material, *e.g.*, ferrite or the like." *Id*., 30:24-26. The individual rotor elements can comprise "an annular arrangement of permanent magnets 634(i), with their poles arranged in an alternating pattern to sequentially oppose and attract the opening of the various solenoid coils of the stator assembly…." *Id*., 30:46-52.

71. Figure 8A provides an exploded view to show how certain components of the device are assembled together:



Id., Fig. 8A.

72. Starting from the bottom of Figure 8A, the lower circuit board assembly 700 includes the stator board and stator elements (blue). *Id*. A shaft 715 (grey) extends through the central hole in the stator board. *Id.*, 33:29-31. Rotor board 850 (red) is positioned above the stator board, with its rotor elements (not shown) positioned opposite the stator elements of the stator board as shown in Figure 6A. *Id.*, Fig. 6A, 30:5-67. A bearing assembly (grey) is mounted on rotor board 850 and rotates around the shaft 715. *Id.*, 34:45-50. Finally, a ranging device control board

840, ranging device 820, and enclosure 830 are assembled above the rotor board 850. *Id*., 34:51-63.

C. Prosecution History

1. I have also reviewed the prosecution history for the '515 Patent. EX1002.

2. I understand the application underlying the '515 Patent was filed on May 18, 2021, with twenty-five claims. EX1002. On July 22, 2021, the Examiner issued Notice of Allowance, finding all claims patentable and making non-substantive amendments to the title and one of the dependent claims. *Id*., 128-131. In his Reasons for Allowance, the Examiner generally repeated the limitations of claim 1 and stated—without explanation—that the prior art of record failed to disclose them. *Id*., 129-130. The Examiner identified one prior art reference as relevant—U.S. Patent No. 8,300,215—but did not explain the basis of its relevance. *Id*. Thereafter, the Applicant submitted a series of Information Disclosure Statements, which then required a series of corrected Notices of Allowance, with the '515 Patent issuing on March 29, 2022.

D. Claims

3. I understand Hesai's Petition challenges claims 1-2, 4-9, 11-14, 16-17, 19-25 of the '515 Patent. These claims are reproduced below:

Claim 1	
1(a)	A light ranging system comprising:
1(b)	an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;
1(c)	a shaft disposed within the enclosure and defining an axis of rotation;
1(d)	a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;
1(e)	a support component rotationally coupled to the shaft and comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;
1(f)	a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;
1(g)	a stator assembly disposed between the first and second planes and coupled to the stator circuit board, the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core;
1(h)	a rotor assembly disposed between the first and second planes and coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and

1(i)	a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and
1(j)	a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.
Claim 2	
2	The light ranging system of claim 1 wherein the shaft is hollow and the system further comprises a communication channel that extends through the hollow shaft allowing ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure in a fixed relationship to the stator circuit board.
Claim 4	
4	The light ranging system of claim 1 further comprising: a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane.
Claim 5	
5	The light ranging system of claim 4 wherein the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth circuit board and the enclosure top with the transmit module mounted to a first portion of the ranging device housing and the receive module mounted to a second portion of the ranging device housing directly adjacent to the first portion
Claim 6	

6	The light ranging system of claim 5 wherein transmit module comprises a fifth circuit board with supporting circuitry for the illumination source and the receive module comprises a sixth circuit board with supporting circuitry for the detector circuitry, and wherein the fifth circuit board is mounted to the first housing portion of the ranging device housing and aligned parallel to the axis of rotation and the sixth circuit board is mounted to the second housing portion of the ranging device housing and aligned parallel to the axis of rotation.
Claim 7	
7	The light ranging system of claim 1 wherein the annular arrangement comprises a plurality of separate permanent magnets.
Claim 8	
8	The light ranging system of claim 1 further comprising circuitry to compute ranging data based on the reflected portion of the electromagnetic radiation pulses.
Claim 9	
9	The light ranging system of claim 1 wherein the stator driver circuit is configured to rotate the rotor assembly at a rate between 10 to 30 Hz.
Claim 11	
11	The light ranging system of claim 1 wherein a number of stator elements in the plurality of stator elements is a multiple of three and the stator driver circuit is configured to provide a 3-phase alternating signal to the plurality of stator elements.
Claim 12	
12	The light ranging system of claim 1 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels.
Claim 13	

13	The light ranging system of claim 12 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).
Claim 14	
14(a)	A light ranging system comprising:
14(b)	an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;
14(c)	a shaft disposed within the enclosure and defining an axis of rotation;
14(d)	a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure;
14(e)	a support component comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve;
14(f)	one or more bearings coupled between the shaft and the support component allowing the support component to rotate around the axis of rotation;
14(g)	a rotor circuit board coupled to rotate with the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover;
14(h)	a stator assembly coupled to the stator circuit board and comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil;
14(i)	a rotor assembly coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles; and

14(j)	a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment; and
14(k)	a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft.
Claim 16	
16	The light ranging system of claim 14 wherein the plurality of magnetic poles rotor in the annular arrangement of the rotor assembly comprise a plurality of separate permanent magnets.
Claim 17	
17	The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement.
Claim 19	

19	The light ranging system of claim 14 wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the illumination source and the detection of reflected portions of the electromagnetic radiation pulses by the receive circuitry.
Claim 20	
20	The light ranging system of claim 14 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels.
Claim 21	
21	The light ranging system of claim 20 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs).
Claim 22	
22(a)	A light ranging system comprising:
22(b)	an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure;
22(c)	a shaft disposed within the enclosure and defining an axis of rotation, the shaft including a hollow channel axially aligned with the axis of rotation and extending through a length of the shaft;
22(d)	a stator circuit board assembly disposed within and coupled to the enclosure in a fixed relationship, the stator circuit board assembly comprising:
22(d.i)	a first circuit board disposed along a plane perpendicular to the axis of rotation;

22(d.ii)	a second circuit board disposed parallel to and adjacent to the first circuit board and having a first aperture formed through a central portion of the second circuit board; and
22(d.iii)	a stator assembly comprising a plurality of stator elements arranged about the axis of rotation;
22(e)	a rotor circuit board assembly disposed within the enclosure and rotationally coupled to the shaft, the rotor circuit board assembly comprising:
22(e.i)	a support component having lower and upper surfaces, a sleeve extending away from the lower surface and fitted over the shaft, a plurality of arms extending away from the sleeve, and a plurality of alignment posts extending away from the upper surface;
22(e.ii)	a third circuit board coupled to the lower surface of the support component and disposed adjacent to and in an opposing relationship with the second circuit board;
22(e.iii)	a fourth circuit board coupled to the upper surface of the support component and arranged parallel with the third circuit board between the third circuit board and the top cover, the fourth circuit board having a plurality of alignment cutouts sized and shaped to accept the alignment posts; and
22(e.iv)	a rotor component coupled to the rotor circuit board assembly and spaced apart from and concentric with the stator assembly, the rotor component comprising an annular arrangement in which a plurality of magnetic segments surround the axis of rotation and are distributed along the annular arrangement in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles;

22(f.i)	a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module and a receive module, the transmit module comprising a bulk transmitting optic and a light source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, the receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment,
22(f.ii)	wherein the detector circuitry comprises a plurality of pixels, each pixel comprising a plurality of single photon avalanche detectors (SPADs) and
22(f.iii)	wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the light source and the detection of reflected portions of the electromagnetic radiation pulses by the detector circuitry
22(g)	a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the rotor component to drive a rotation of the second circuit board assembly and the light ranging device about the shaft;
22(h)	a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement; and
22(i)	a communication channel extending through the hollow channel in the shaft and operatively coupled to allow ranging data from the light ranging device to be transmitted to circuitry disposed within the enclosure in a fixed relationship to the stator circuit board assembly.

Claim 23	
23	The light ranging system of claim 22 wherein the plurality of stator elements and the annular arrangement of the plurality of magnetic segments are each disposed between a surface of the second circuit board and a surface of the third circuit board.
Claim 24	
24	The light ranging system of claim 22 wherein each magnetic segment in the annular arrangement of the rotor component comprises a permanent magnet.
Claim 25	
25	The light ranging system of claim 22 wherein the light source comprises a plurality of emitters configured to project a plurality of illuminating beams in a field ahead of the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of pixels.

VIII. OVERVIEW OF PRIOR ART REFERENCES

1. U.S. Patent Pub. No. 2014/0211194 ("Pacala")

73. Pacala is titled, *Cost-effective LiDAR Sensor for Multi-signal Detection, Weak Signal Detection and Signal Disambiguation and Method of Using Same*. EX1004. I understand that Pacala was filed on January 27, 2014 and published July 31, 2014. *Id.* Thus, I have been informed that it qualifies as prior art because it was filed and published more than a year before the priority date of the '515 Patent.

74. Pacala names three inventors: Angus Pacala, Tianyue Yu, and Louay Eldada. *Id.* Mr. Pacala is a named inventor on the '515 Patent. EX1001.

75. I understand that Pacala was assigned to Quanergy Systems, Inc., which is the LiDAR company that Mr. Pacala worked for before founding Ouster. EX1004.

76. Pacala states that it employs "cost-effective robust time-of-flight (ToF) lidar sensors for real-time wide-field-of-view three-dimensional mapping and object detection…." EX1004, [0003]. The LiDAR sensor of Pacala is shown below:

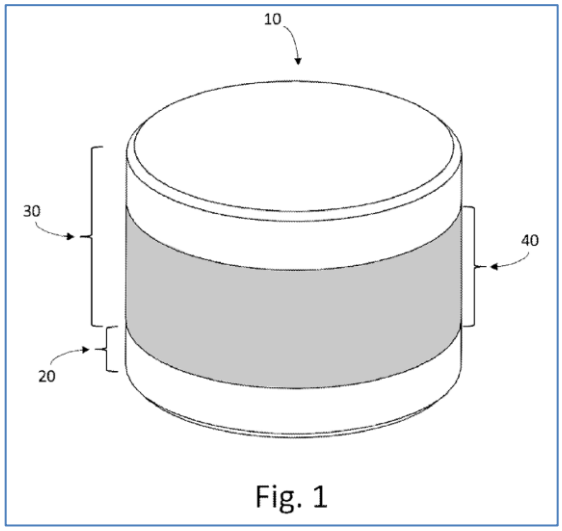


Fig. 1

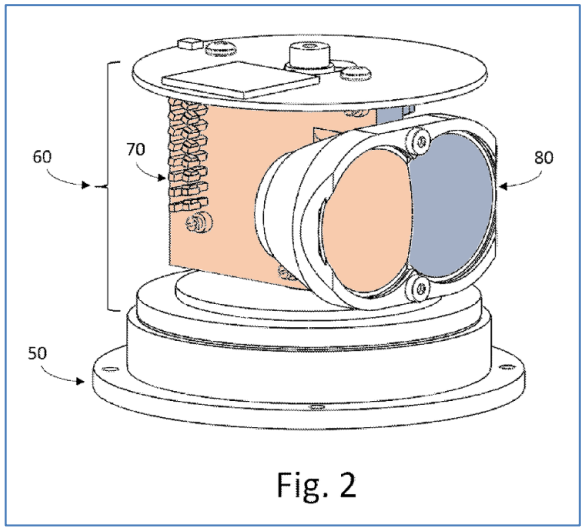


Fig. 2

Id., Figs. 1-2.

77. As can be seen in these figures, the LiDAR system includes a static base 20/50 and a rotating turret 60. *Id.*, [0012]-[0013]. The static base "contains a motor and distributed electronics, and the spinning turret 60 contains optoelectronics components 70 (including optical transmitters and receivers), lenses 80, and distributed electronics. *Id.* Although Pacala does not detail the implementation of the fixed base and rotating turret, it would have been obvious to use known motor design as, as I discuss later in this declaration.

78. Pacala explains that optoelectronics components 70 include transmitters for emitting pulses and detection circuitry in the form of pixels, which may be implemented using single-photon avalanche diode ("SPAD") arrays: "The multi-channel TDC electronic circuitry with multiple voltage thresholds can be implemented with discrete integrated circuits (ICs), in the form of FPGA logic, as part of an application-specific integrated circuit (ASIC), or integrated into the pixels of a detector array (*e.g.*, Single-Photon Avalanche Diode [SPAD] array)." *Id*., [0012]-[0014].

79. Pacala also discloses collimation and focusing lenses 80 that are shown in Figure 2. *Id*., [0013], Fig. 2. The transmitters and collimation lens 80 form a bulk transmit module for generating and transmitting light pulses, while the detectors and focusing lens form a bulk receiver module for receiving and processing returned light, as reflected by the blue and orange annotations in Figure 2 above. A window 40 (grey) surrounds the enclosure and is transparent to allow light pulses to be emitted and received by the internal LiDAR components, as reflected by the grey annotation in Figure 1 above. *Id.*

80. Pacala is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

2. U.S. Patent No. 10,790,077 ("Johnson")

81. Johnson is titled, *Devices and Methods For An Electromagnetic Coil*.

EX1005. I understand that Johnson is prior art to the '515 Patent because it was filed on October 31, 2016, prior to the priority date of the '515 Patent.

82. Johnson is assigned to Waymo, LLC, which is the autonomous vehicle subsidiary of Alphabet, Inc. *Id*.

83. Johnson provides "example implementations" for electromagnetic coils that can be used with a "rotary joint device" comprising a "rotor[] configured to rotate relative to a [] stator," including a rotary joint device for "LIDARs." *Id*., Abstract, 6:49-59. For instance, Johnson discloses that its implementation of electromagnetic coils can be applied to a stator assembly of a motor. *Id*., 11:66-15:53, Figs. 2, 3A-3D.

84. Johnson also discloses embodiments in which the motor is a printed circuit board motor (or "PCB motor" for short) that rotates the rotor platform relative to a fixed stator platform about an axis of rotation. *Id*., 13:58-60, 7:6-21, 10:62-67, 11:65-12:18, Figs. 3B-3D. Thus, like the '515 patent, Johnson teaches the use of a PCB motor integrated into the rotor and stator platforms to provide a more compact and efficient use of space. Indeed, another Waymo patent describes a similar "PCB motor" (*Compare* EX1045, Figs. 4B-4D *with* EX1005, Figs. 3B-3D) and explains that by implementing the motor "as components included and/or mounted to the rotor and stator platforms," the PCB motor provides a "more compact and/or efficient use of space." EX1045 (Karplus), 4:1-6; *see also* EX1001 ('515 patent),

30:10-15 ("The stator and rotor assemblies of the electric motor can be integrated onto the boards of the rotary actuator 608, i.e., the elements of the electric motor are one of many components on the surface of the printed circuit boards and thus a separate motor module is not required for LIDAR system 600.").

85. Figure 2 shows a functional block diagram of the rotor-stator assembly. The first platform 210 (red) represents the rotor elements, whereas the second platform 230 (blue) represents the stator elements:

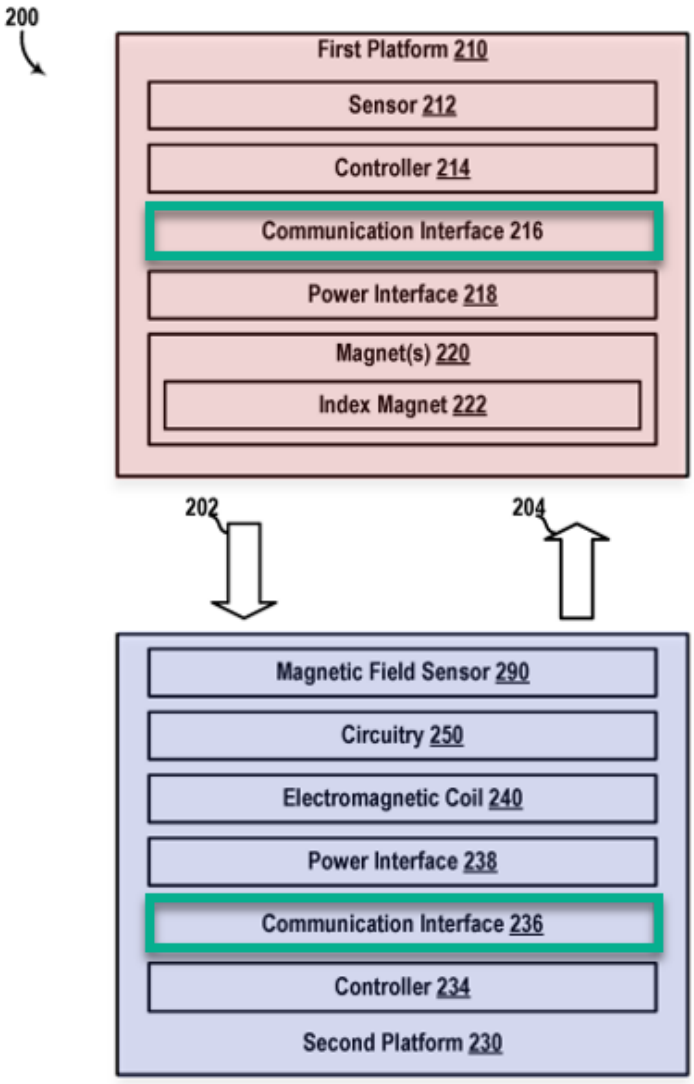


FIG. 2

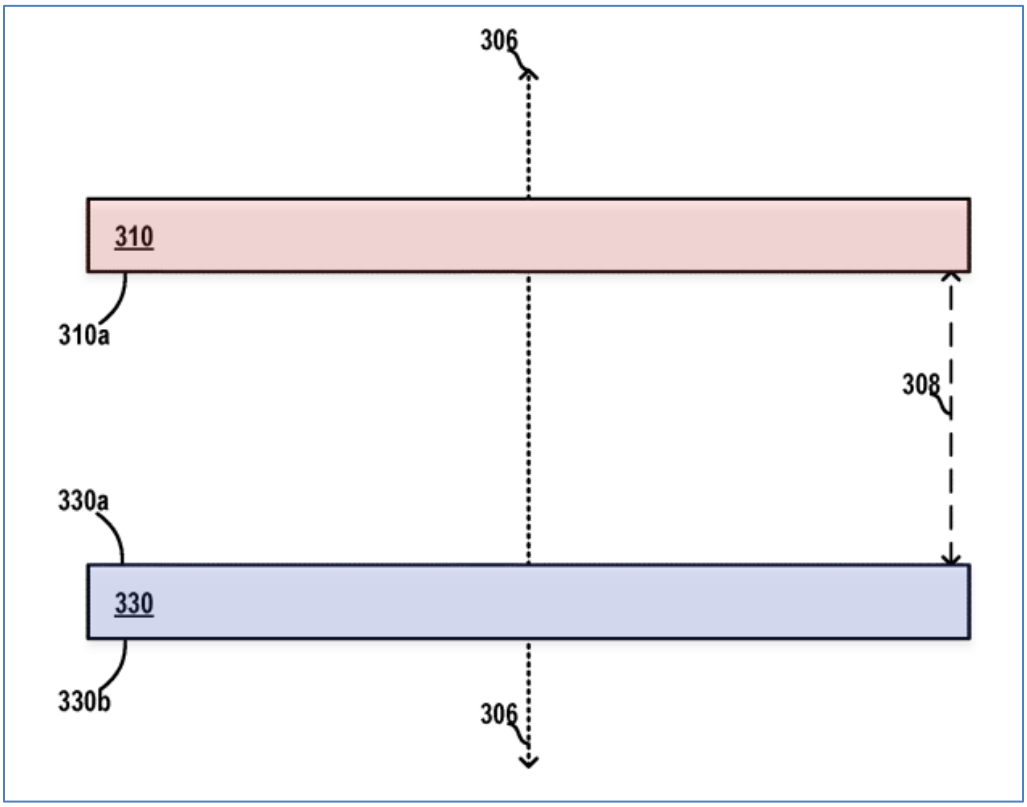
Id., Fig. 2. The "sensor 212" is integrated onto the rotor platform 210 and may be "LiDAR." *Id*., 7:22-27.

86. Platform 210 "may comprise any solid material suitable for supporting and/or mounting various components of platform 310" and "may include a printed circuit board (PCB)" that mounts communication interface 316 and/or other components of platform 310." *Id*., 7:6-21. The sensor 312 may include "remote

sensing devices" such as "LIDARs." *Id*., 7:45-27. Magnets 320 form the rotor elements of the device and can be formed as discrete magnets with alternating polarity. *Id*., 11:4-15. Alternatively, the magnets can be implemented "as a single ring magnet that is concentric to the axis of rotation of the first platform." *Id*., 8:33-48.

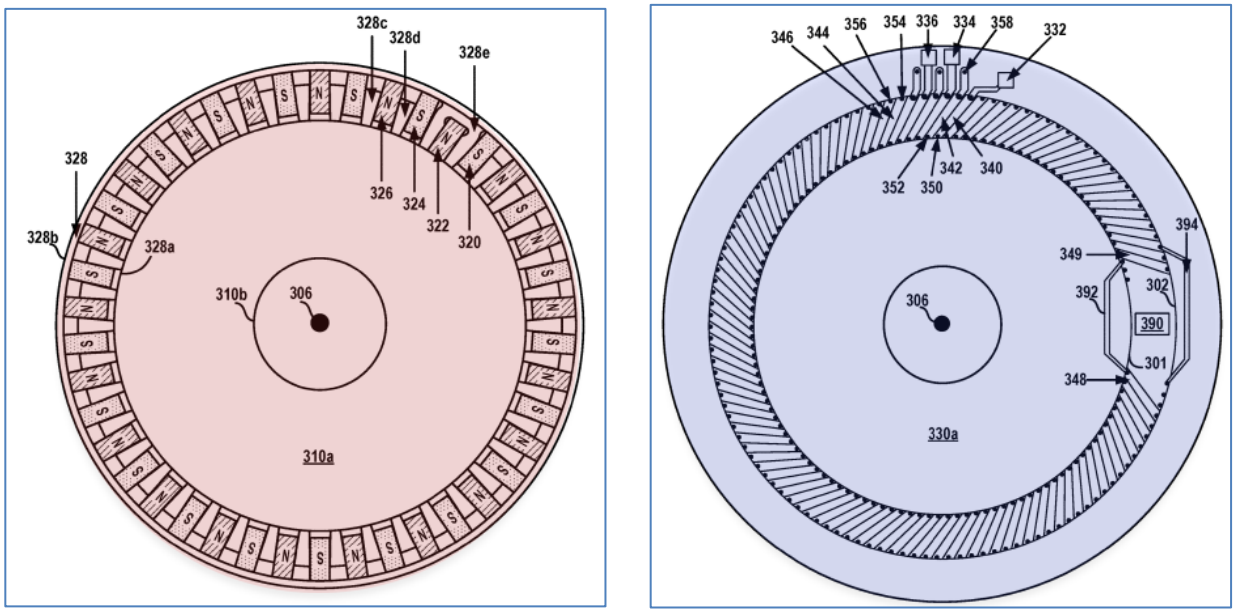
87. Platform 230 "can be configured as a stator platform in a rotary joint configuration" and "formed from any combination of solid materials suitable for supporting the various components mounted or otherwise coupled to platform 330." *Id*., 8:54-67. For example, "platform 230 may comprise a circuit board that mounts one or more components (*e.g.*, interfaces 236, 238, sensor 290, etc.). *Id*. Electromagnetic coil 240 forms the stator elements. *Id*., 9:32-34.

88. Figure 3A provides another view of the assembly, with rotor platform 310, stator platform 330, and axis of rotation 306:



Id., Fig. 3A, 10:48-62.

89. Figures 3B and 3C, which are shown on the left and right (respectively) show the underside of the rotor platform 310a and the upper side of the stator platform 330a:



Id., Figs. 3B-C.

90. The rotor platform includes a plurality of magnets mounted concentrically on the underside surface 310a on mount 328. *Id*., 11:15-36. Johnson explains that the platform "may include additional components," for example, a transformer coil arranged around the edge of the center gap 310b to provide for power transmission between the rotor and stator, and wireless transmitters or receivers. *Id*., 11:51-65.

91. The stator platform sits opposite the rotor platform. *Id*., Figs. 3A, 3C-3D, 7:15-21, 10:47-54. The upper surface 330a includes a plurality of stator elements opposite the rotor elements on the lower surface 310a of the rotor platform, as well as driver circuitry 250 that provides a 3-phase AC signal through the coils of the stator elements. *Id*., 9:32-47, 6:35-40. The current flow causes a "stator-

platform magnetic field" to form, which interacts with the "rotor-platform magnetic field" associated with the magnets mounted on rotor platform 310 "to cause a torque or force that rotates platform 310 about axis 306." *Id*., 13:51-58.

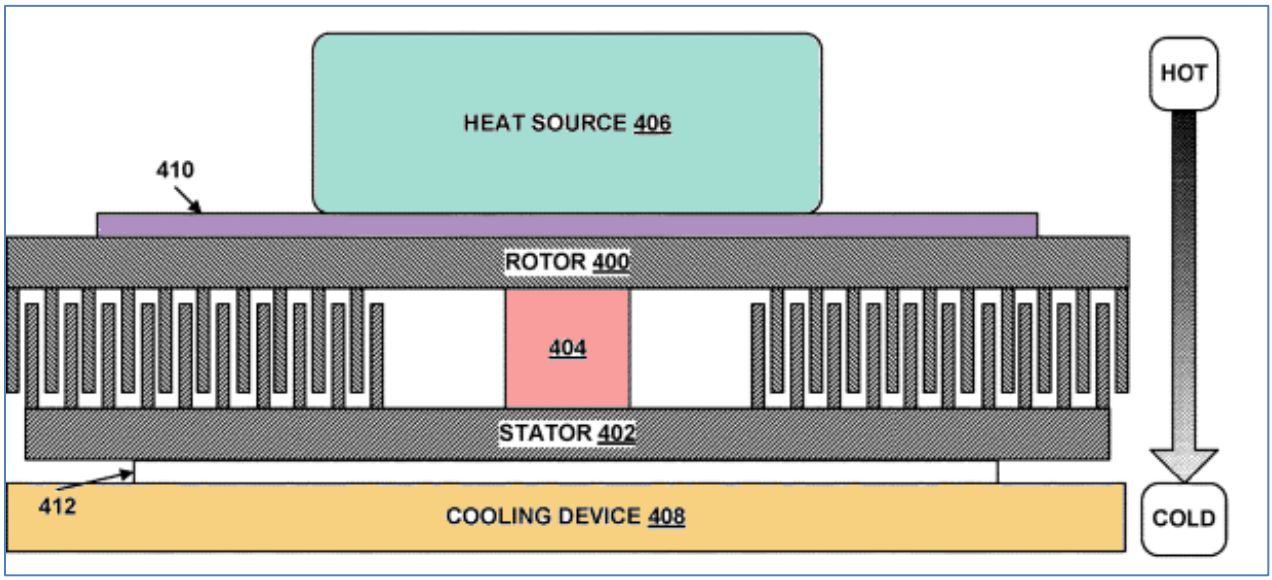
92. Johnson is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

3. U.S. Patent No. 10,749,308 ("Pardhan")

93. Pardhan is titled, *Thermal Rotary Link*. EX1006. I understand Pardhan is prior art because it was filed on October 17, 2016, prior to the priority date of the '515 Patent. *Id*.

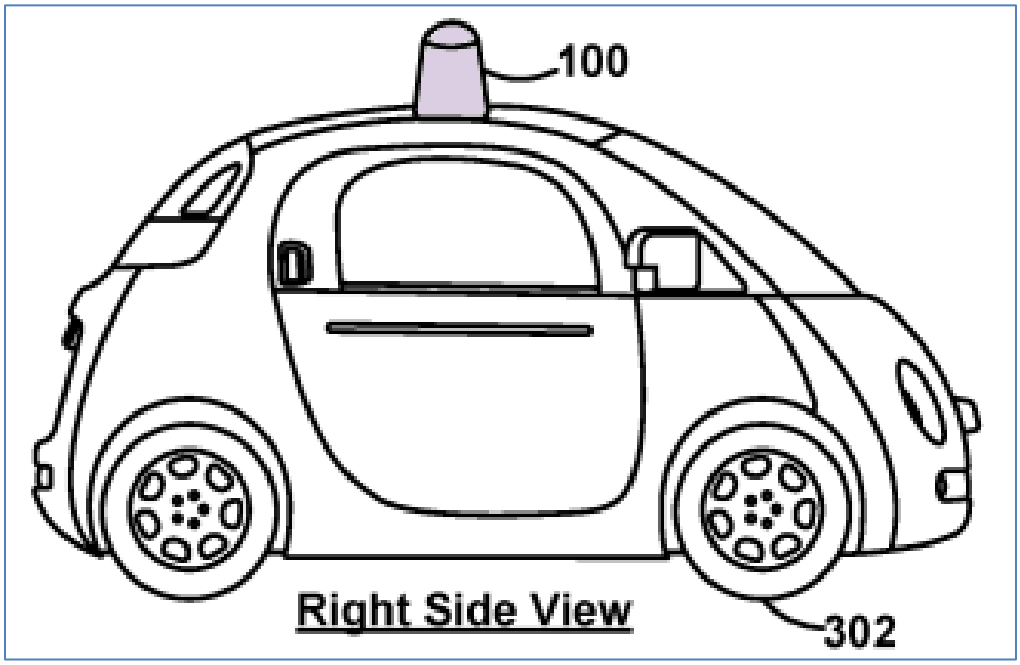
94. Like Johnson, Pardhan is a patent assigned to Waymo.

95. Pardhan describes a thermal rotary link. *Id*., Abstract. The thermal rotary link includes a rotor plate (400) connected to a stator plate (402) by way of rotational joint (red), as well as a plurality of fins on each that are arranged to transfer heat from a heat source (green) to a cooling device (orange):



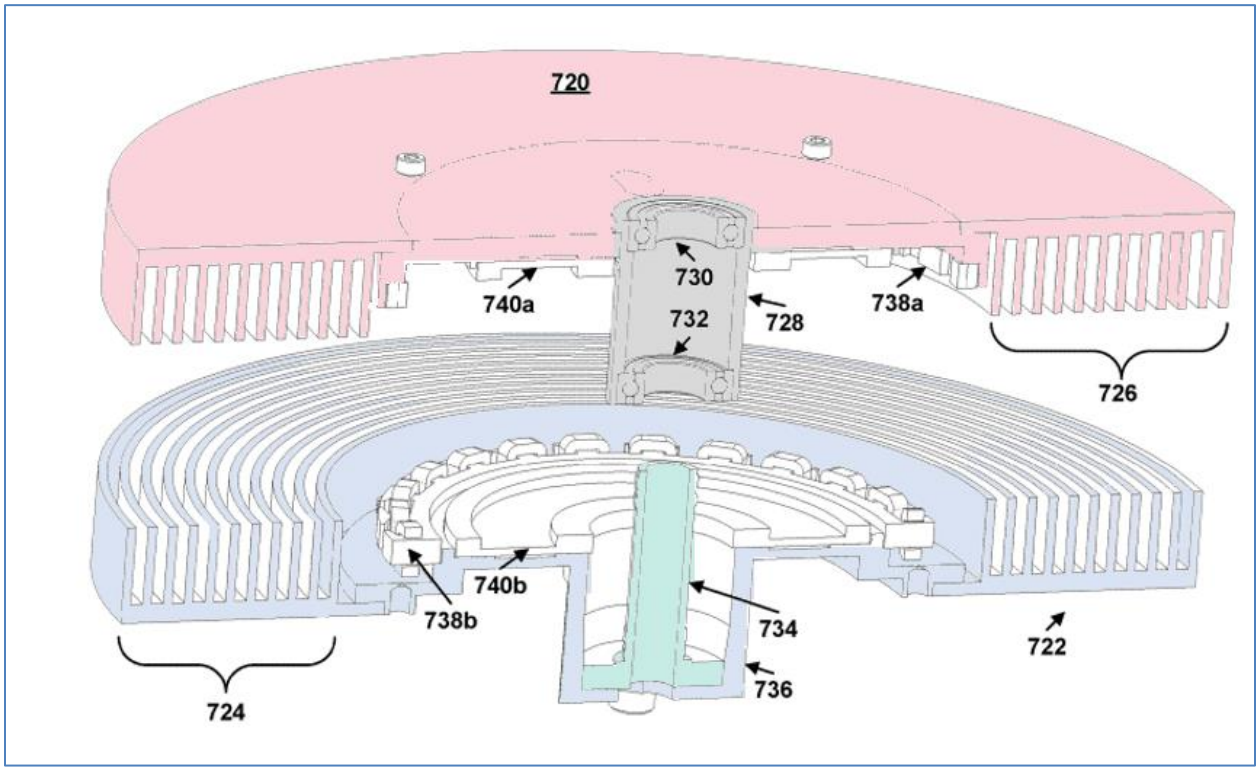
Id., 1:27-47, 10:61-67, 16:49-64, Fig. 4.

96. Pardhan teaches that the heat source device may be a "rotating LIDAR device" that is directly coupled to the rotor or coupled by way of coupling 410 (purple), such as LiDAR on the top of a vehicle:



Id., 3:3-6, 16:65-17:5, 17:55-62; Fig. 3.

97. Figure 7B shows a cross-section of the thermal rotary link. *Id.*, 7:40-51. A stator plate (blue) is coupled to a hollow shaft 734 (green) extending upward along the vertical axis of rotation, and the rotor plate (red) is coupled to a hollow sleeve 728 (grey) that fits over the shaft and rotates about the shaft via bearings 730 and 732:



Id., Fig. 7B. The rotor plate 720 (along with its fins) may be manufactured as "one piece" that is made from a "metallic material with high thermal conductivity" so as to transfer heat away from the LiDAR device. *Id.*, 18:6-19.

98. Figure 7A illustrates an example in which a "rotating LIDAR device" (704) is attached to the thermal rotary link. *Id.*, 19:54-20:11. The rotational platform containing the rotor plate (red) is connected to a fixed base containing the stator plate

(blue) by way of a rotational joint system that includes rods/shafts (green), and the exemplary LiDAR device (704) is mounted on the rotor top:

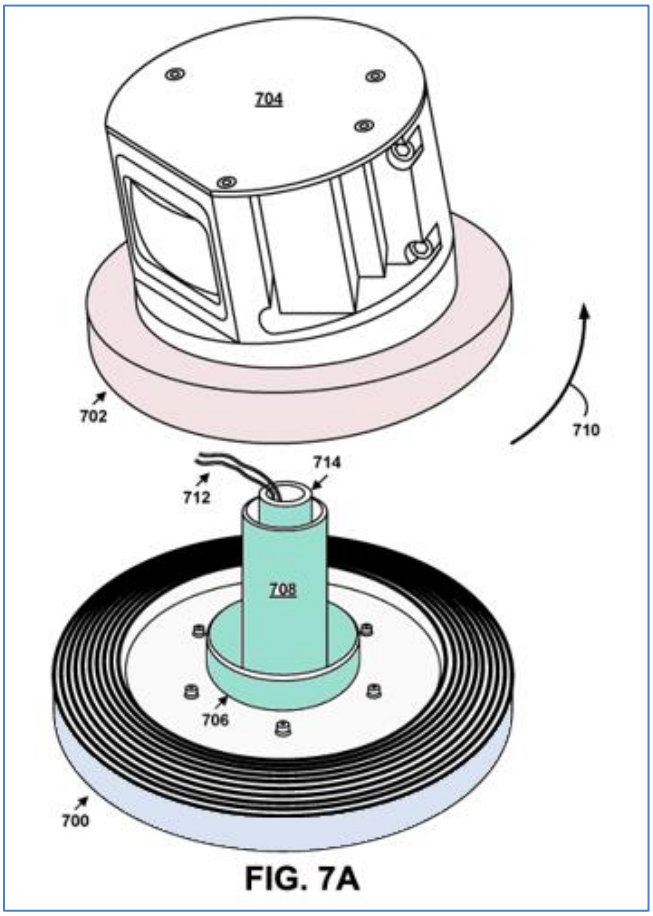


FIG. 7A

Id., Fig. 7A. The rotational joint system includes a hollow shaft that provides wired data connections between the rotator and stator platforms. *Id*., 4:17-25.

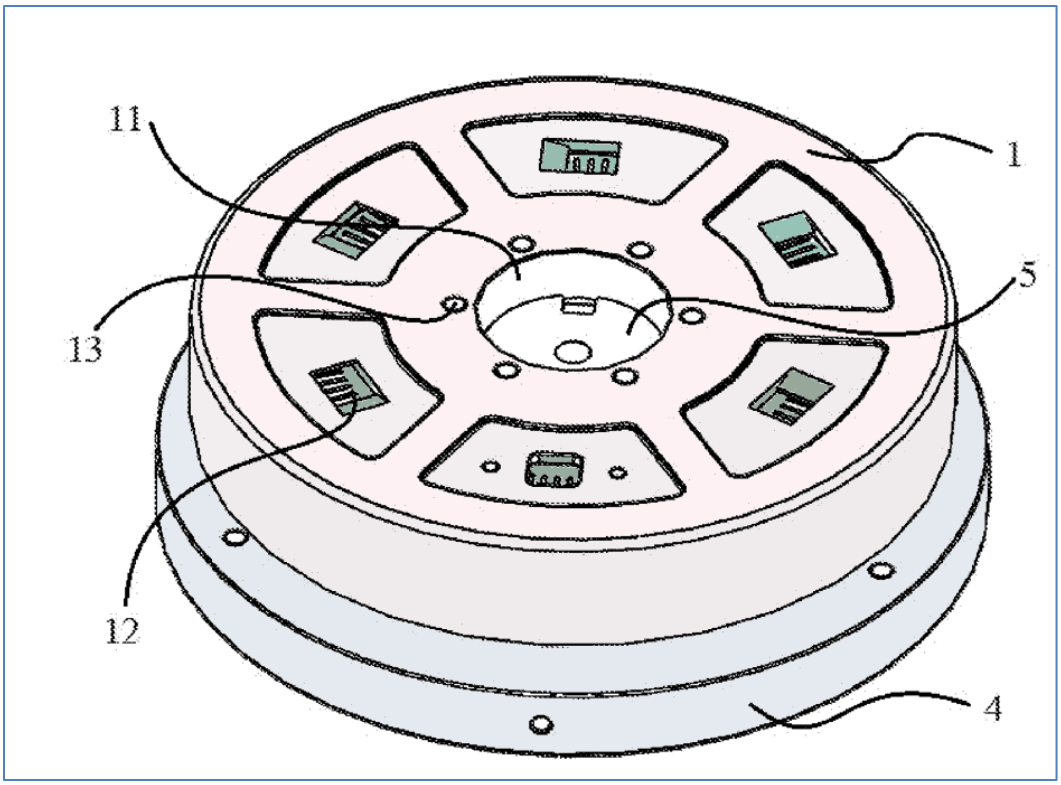
99. Pardhan is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

4. WO 2018/201567 ("Zhang")

100. Zhang is titled *Rotating Structure For Laser Radar*. EX1007. I understand that Zhang is prior art because it was filed on June 16, 2017 and was

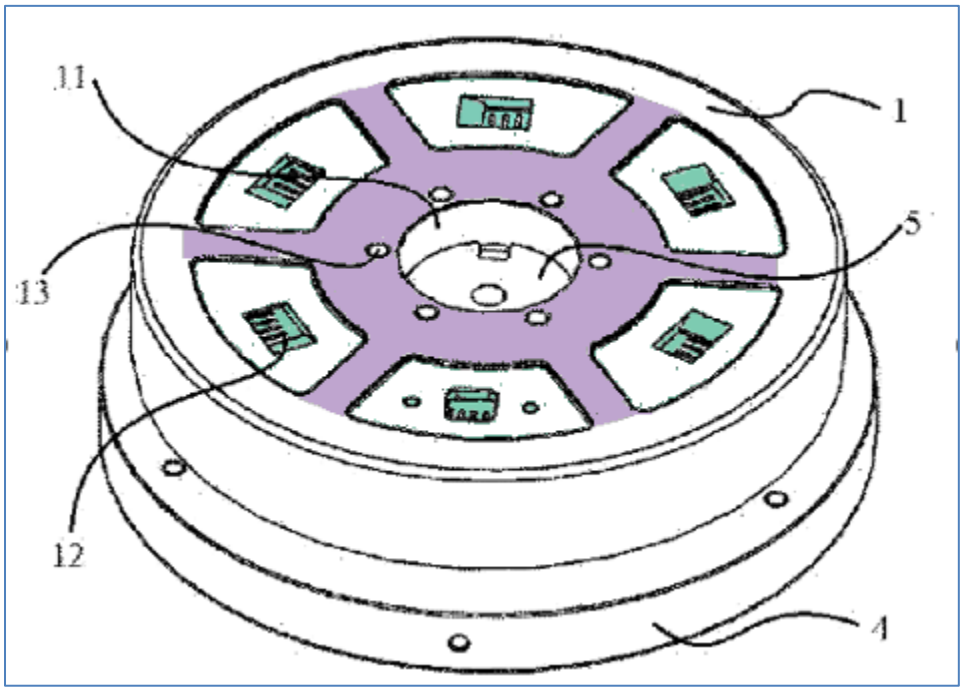
published on November 8, 2018, before the priority date of the '515 Patent. Zhang is assigned to Hangzhou Ole-Systems Co., Ltd., which I understand is a company that makes LiDAR sensors. http://ole-systems.com/index.php?catid=26.

101. Zhang teaches a rotating structure for a laser radar device, such as LiDAR. *Id*., Abstract. Figure 1 is a diagram of the rotating device, which includes a fixed stator (blue) and a rotor (red).



Id., Abstract, pg. 4, Figs. 1, 3.

102. The rotor structure also includes arms (purple) that extend outwards from the shaft with heat dissipation holes (green) disposed between each arm:



Id. Zhang teaches that its support structure is beneficial because it allows "the heat generated during the operation of the rotating structure" to "be released" through the heat dissipation holes, thereby "increasing the operating life of the rotating structure." *Id*., pg. 6.

103. Further, Zhang explains that by having "a hollow shaft" there is "enough space in the middle to accommodate a signal transmission structure" that provides a communication channel through the hollow shaft. *Id.*, Abstract, pg. 3, 5 ("a through hole (51) is configured in the center of first coupling coil (5), and signal transmission unit is configured in through hole, which further saves the space of the external signal transmission unit while preventing interference between various transmission units or cables."), Fig. 4.

104. Zhang is analogous art to the '515 patent because it is in the same field

of endeavor, *i.e.*, structures and components for rotating ranging systems.

5. CN205027903U ("Cai")

105. Cai is titled *Laser Ranging Module*. EX1008. Cai was filed on October 13, 2015 and published on February 10, 2016. *Id*. I understand it is prior art because it was filed and published before the priority date of the '515 Patent.

106. Cai is assigned to "Shenzen Han's Lidar Technology Co., Ltd." and discloses a laser ranging device that can use Time-of-Flight to measure distances to objects. *Id*., [0001]-[0002]. The laser ranging device (1) is shown in Figure 1 and includes a rotating disk (red) and base (blue):

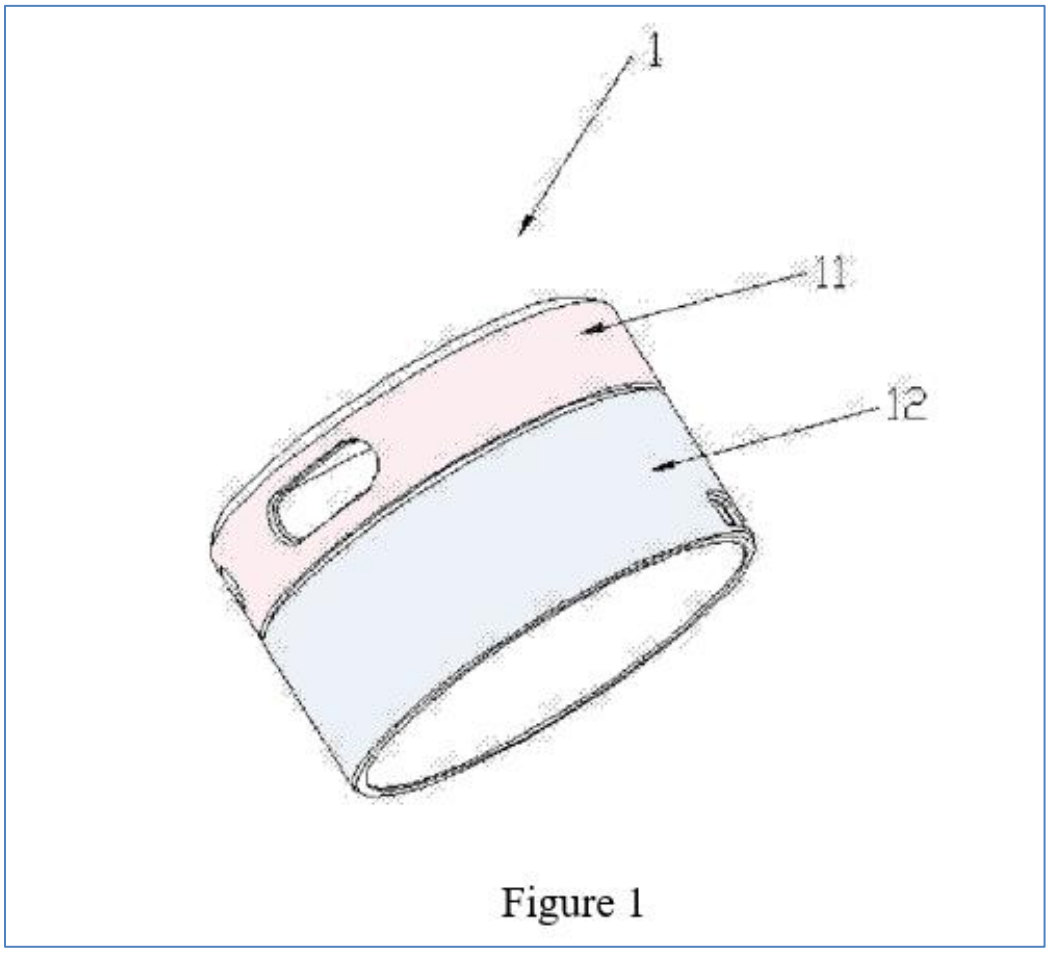


Figure 1

Id., Fig. 1, [0025].

107. Cai teaches that its device includes a wireless power transformer whose primary and secondary coils are positioned on the outside of the motor elements in an arrangement that provides high power conversion efficiency. *Id*., [0004].

108. Figures 3 and 5 illustrate the inside of the rotating disk and base:

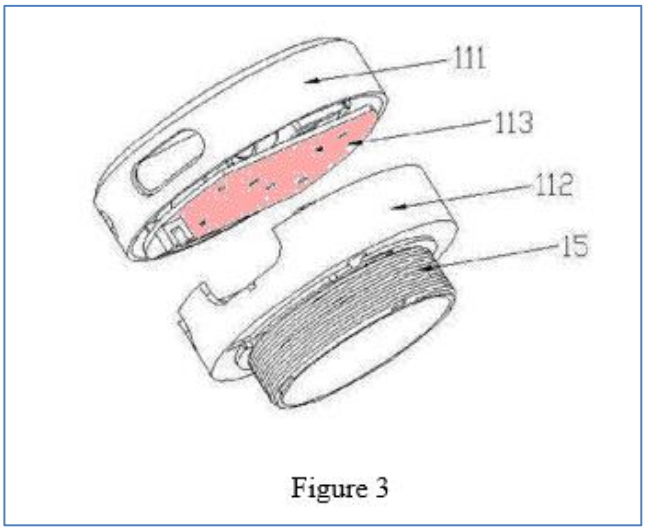


Figure 3

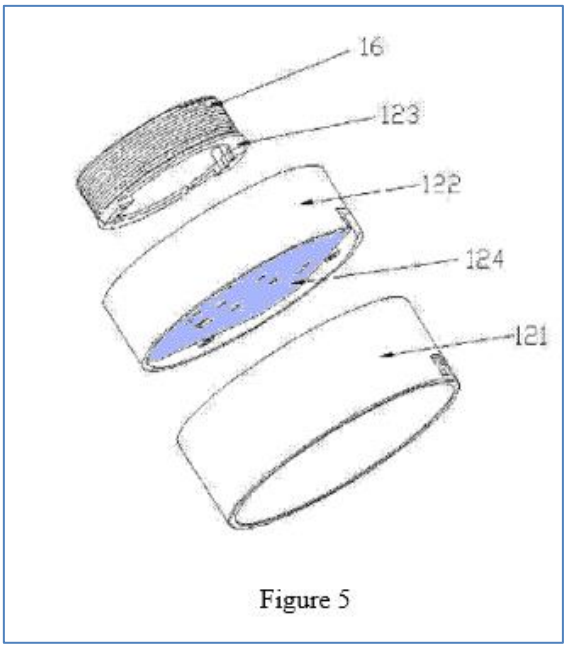


Figure 5

Id., [0026], [0028], Fig. 3, 5. A first a first circuit board (124) is part of the fixed base and a second circuit board (113) is part of the rotating disk. Primary and secondary transformer coils (15/16) are also shown.

109. The primary and secondary transformer coils are positioned outside of the motor that is shown in Figure 4 (below). The motor includes a "through hole" (131). *Id*. The through hole allows "signal transceiver devices (17)" mounted on the first and second circuit boards to exchange "sensor data." *Id*.

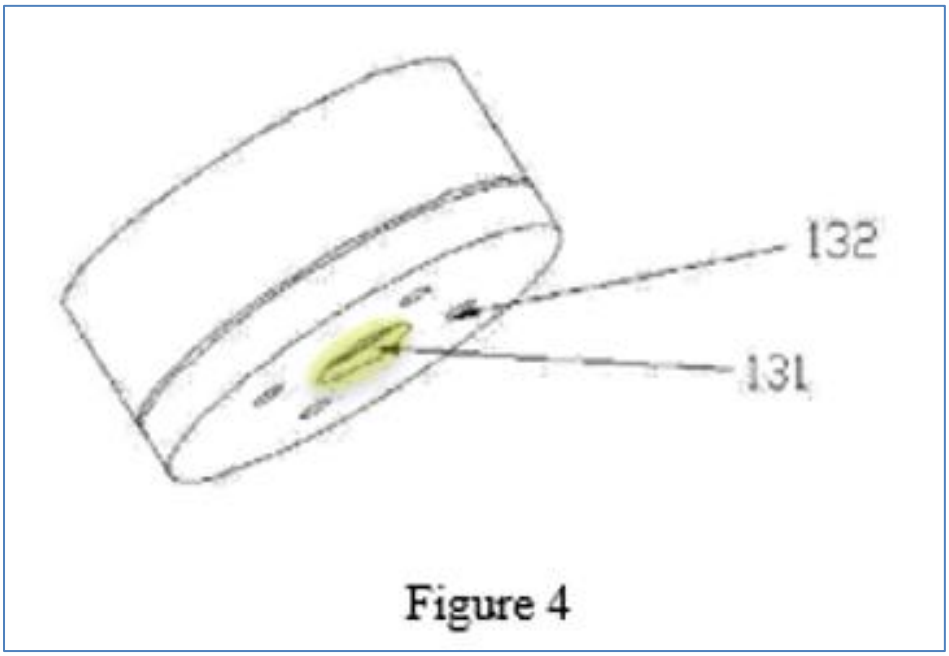
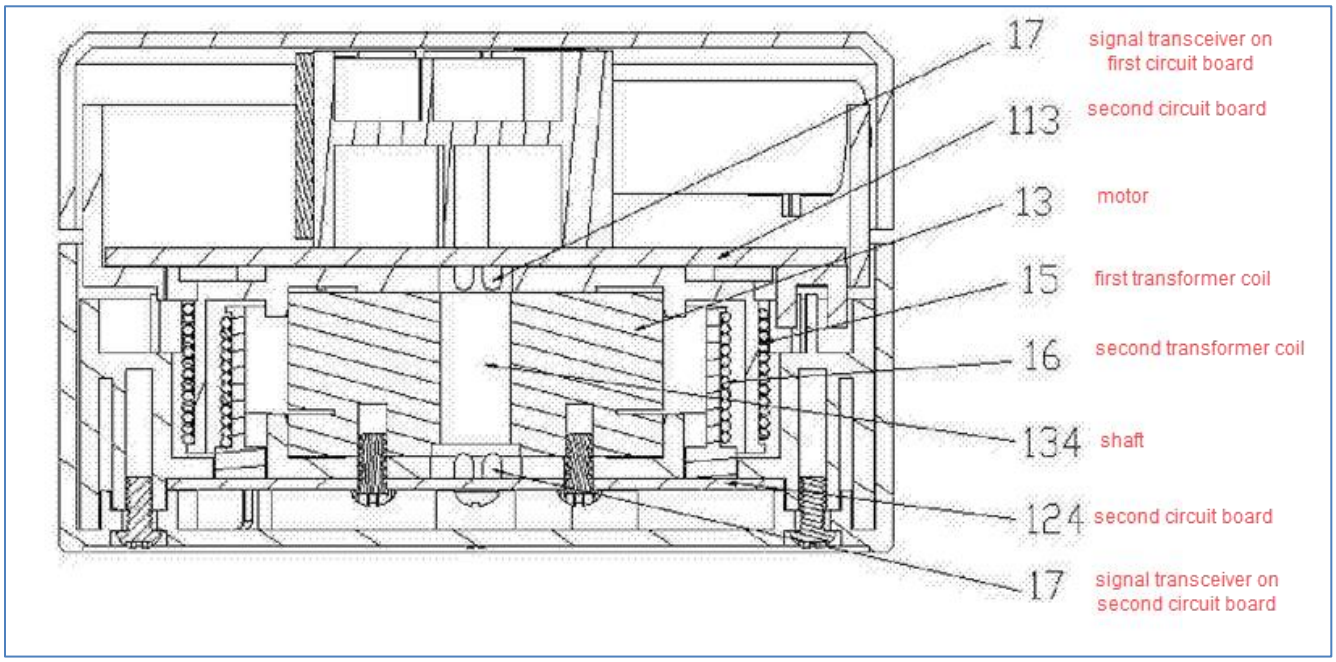


Figure 4

Id., [0027], [0030]. Fig. 4.

110. Figure 8 illustrate the signal transceivers (17) mounted at the center of each of the first (124) and second (113) circuit boards, and the motor (13) positioned in the center with the transformer coils (15/16) on the outside of the motor:



Id., Fig. 8.

111. Cai is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

6. U.S. Patent No. 11,723,762 ("Hall")

112. Hall was filed on January 31, 2017. EX1009. It therefore qualifies as prior art under 35 U.S.C. § 102(a)(2).

113. Hall's LiDAR system includes "an array of multiple laser emitters and detectors" and may be used for "autonomous vehicle application[s]." *Id.*, 1:64-2:14. A principal embodiment is a LiDAR system shown in Figure 3:

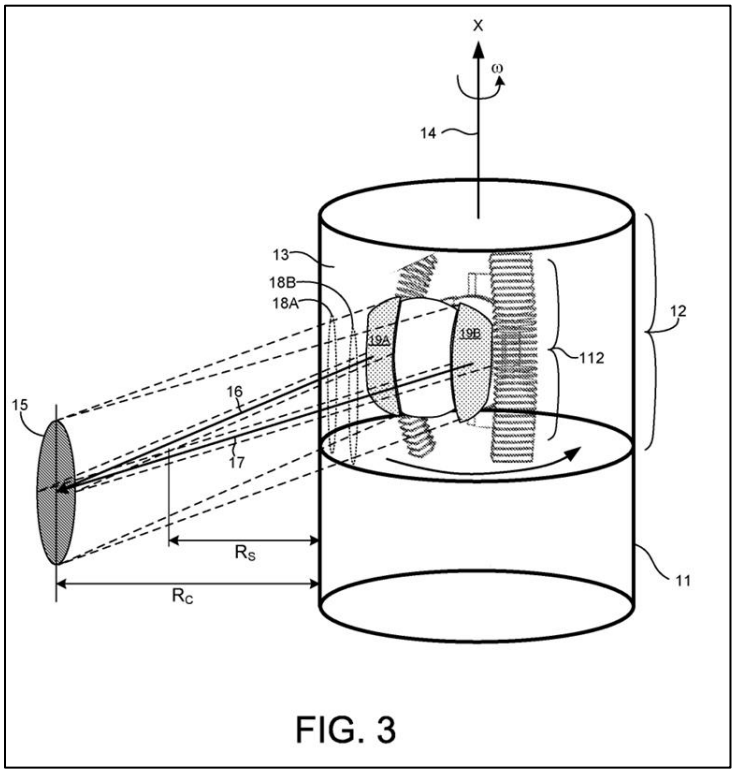


FIG. 3

Id., Fig. 3.

114. The LiDAR system 10 includes a lower housing 11 and an upper

housing 12, with a transparent cylindrical shell element 13. *Id.*, 5:52-60. The system includes a "light emission/collection engine 112" that is connected to a "rotating electronics board 111" to rotate about a central axis. *Id.*, 4:45-64. The light emission/collection engine includes "an array of light emitting elements 114 and an array of light detecting elements 113." *Id.*, 4:65-67. Light from the emitters "passes through a series of illumination optics 115 that collimate the emitted light" and emit the light into the environment. *Id.*, 5:2-5. The light is then "reflected from objects in the environment" and "collected by collection optics 116 … where it is focused onto each detecting element of the array of detecting elements 113." *Id.*, 5:8-14.

115. Hall is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

7. U.S. Patent No. 10,473,766 ("Spector")

116. Spector is titled *Light detection and ranging (LiDAR) system and method*. EX1010. It was filed on June 27, 2017. *Id*. I understand that it is prior art because it was filed before the priority date of the '515 Patent.

117. Spector teaches a LiDAR system that includes a "receiver optics" with "an array of optical detection sites" comprising a "pixelated optical sensor array 20" and "an aperture array 18 for defining the optical detection sites on the sensor array." *Id.*, 3:32-45. Spector explains that the aperture array has a "mask" that defines "a plurality of transparent apertures arranged according to the two dimensional array"

of detectors. *Id.*, 3:57-59. Spector's receiver optics are illustrated on the right side of Figure 1:

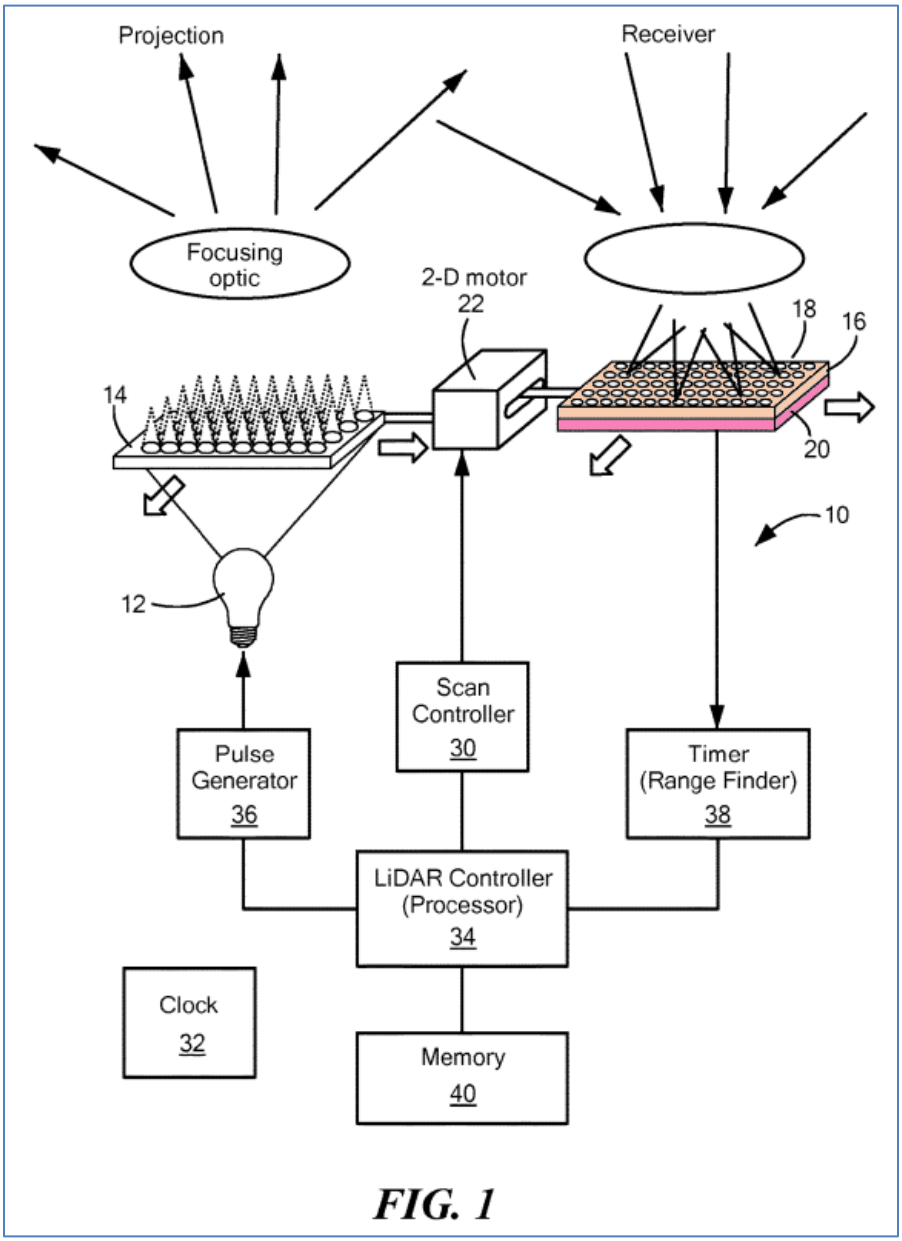


FIG. 1

Id., Fig. 1.

118. Spector explains that the aperture array is "beneficial to establish the individual optical detection sites." *Id.*, 3:54-56. Specifically, each aperture "limits

visibility by each optical detection site to a single corresponding light spot" from a plurality of light spots generated by a corresponding light transmission module. *Id.*, 3:59-61; *see also id.*, 3:1-14. As a result, the "array of light spots" generated by the light transmission module "is received in one-to-one correspondence to the array of optical detection sites." *Id.*, 5:33-35. By using "a two dimensional array of isolated light spots and individual optical detection sites in one-to-one correspondence with those spots," Spector is able to reduce "cross-talk and multipath signal … advantageously." *Id.*, 6:12-15.

119. Spector is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

8. U.S. Patent No. 10,605,984 ("Droz")

120. Droz is titled *Array of Waveguide Diffusers for Light Detection Using an Aperture*. EX1011. I understand Droz is prior art because it was filed on December 1, 2016, before the priority date of the '515 Patent. *Id.*

121. Like Johnson, Pardhan and Johnson, Droz is a patent that issued to Waymo. In fact, the first named inventor on Droz is Pierre-Yves Droz, who is also an inventor on the Pardhan patent. *Id*.

122. Droz discloses a waveguide array 360 that includes waveguides which direct light to a particular array of light detectors (310, 316, 318), as shown in Figure 3:

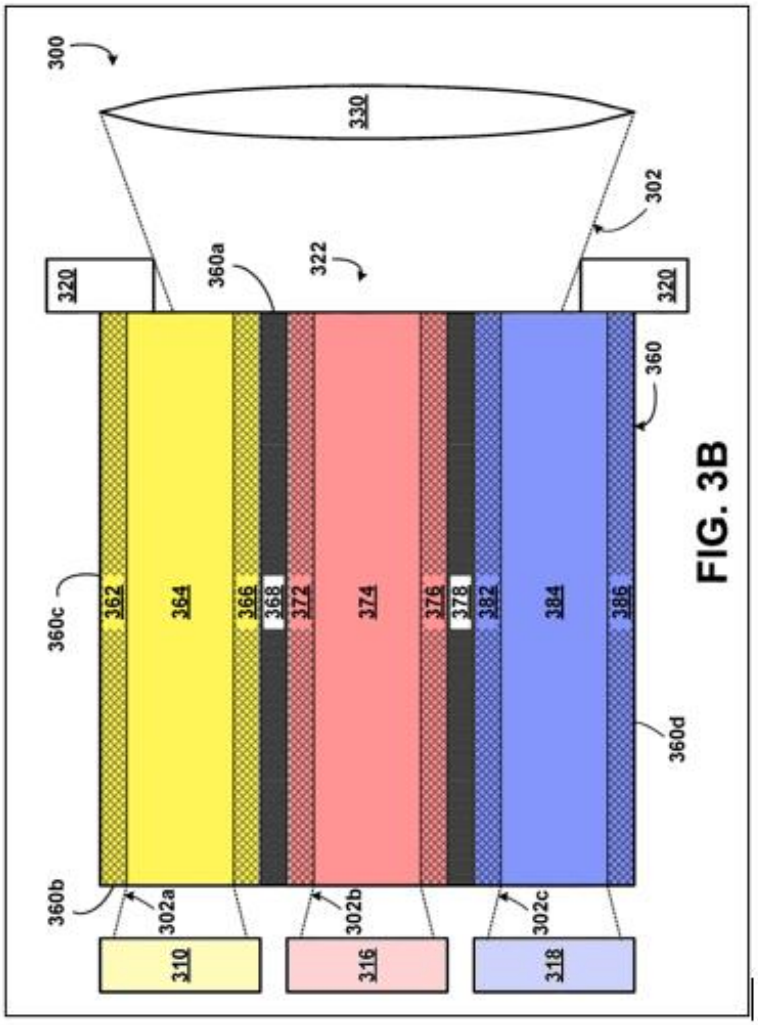


FIG. 3B

Id., 13:23-54. Droz explains that the array of light detectors may be part of a LiDAR device and can improve the device's sensitivity to low intensities of light, "thereby enhancing their detection qualities." *Id.*, 1:10-23, 3:2-7. For example, an "array of SPADs can be connected in parallel to one another, which may allow combining the signals from the connected SPADs to improve the sensitivity of the system." *Id.*, 3:63-67. Droz is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

9. U.S. Publication No. 2018/0003823 ("Yan")

123. Yan is titled *Rotary Type Distance Sensing Device*. EX1012. Yan was filed on April 28, 2017 and published on January 4, 2018. *Id*. I understand that it is prior art because it was filed and published before the priority date of the '515 Patent.

124. Yan discloses "a range detecting device which can rotate 360 degrees." *Id*., [0007]. Yan's ranging device "mainly comprises a fixing base, a rotating mount, and a control module." *Id*., [0008].

125. Figure 1 illustrates the ranging device (purple), which comprises a transmitter (yellow) for transmitting a signal used to measure distance to an object and a receiver (orange) for receiving the reflected signal:

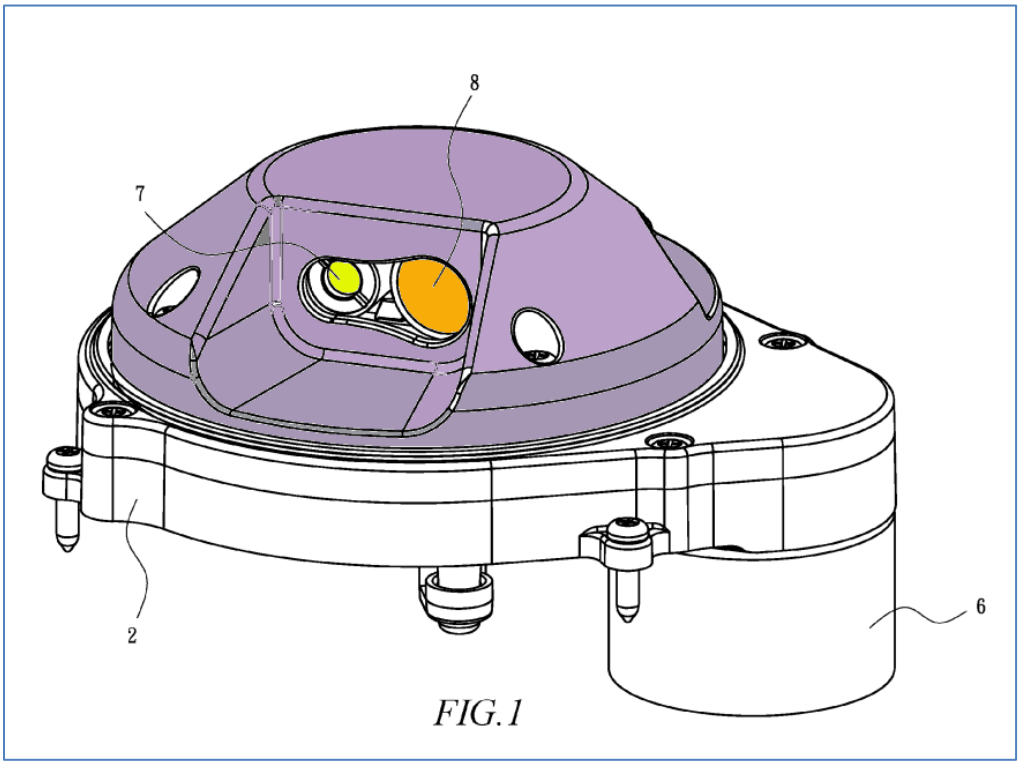


FIG. 1

Id., Fig. 1.

126. Yan teaches that a control module of a ranging device (orange) may be mounted to the rotating platform (red), which is coupled to a fixed base (blue), using alignment posts (green) and alignment cutouts (boxes), as shown in Figure 4:

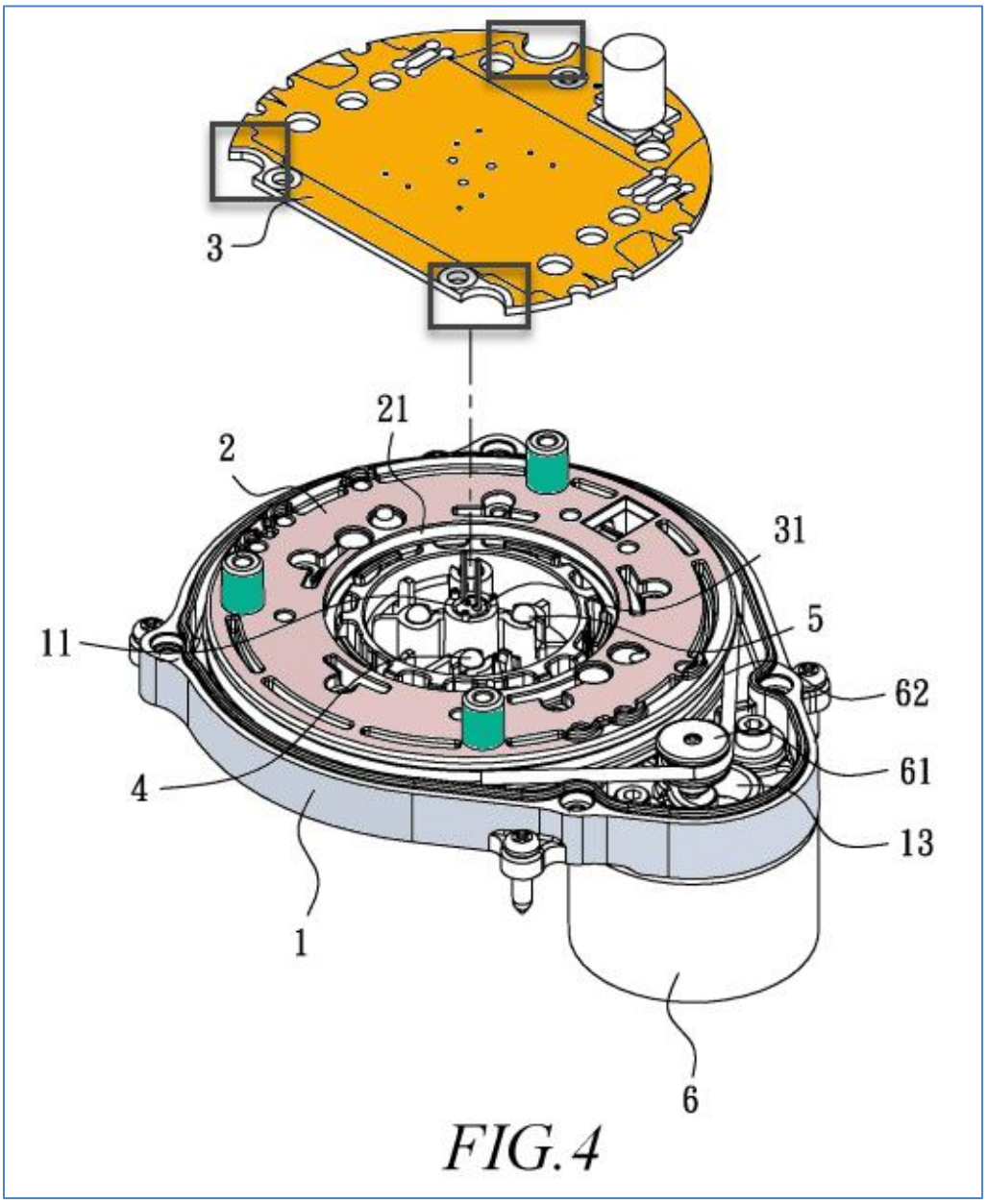


FIG.4

EX1012, [0005]-[0007], [0068], [0070]-[0071], Fig. 4.

127. Yan is analogous art to the '515 patent because it is in the same field of

endeavor, *i.e.*, structures and components for rotating ranging systems.

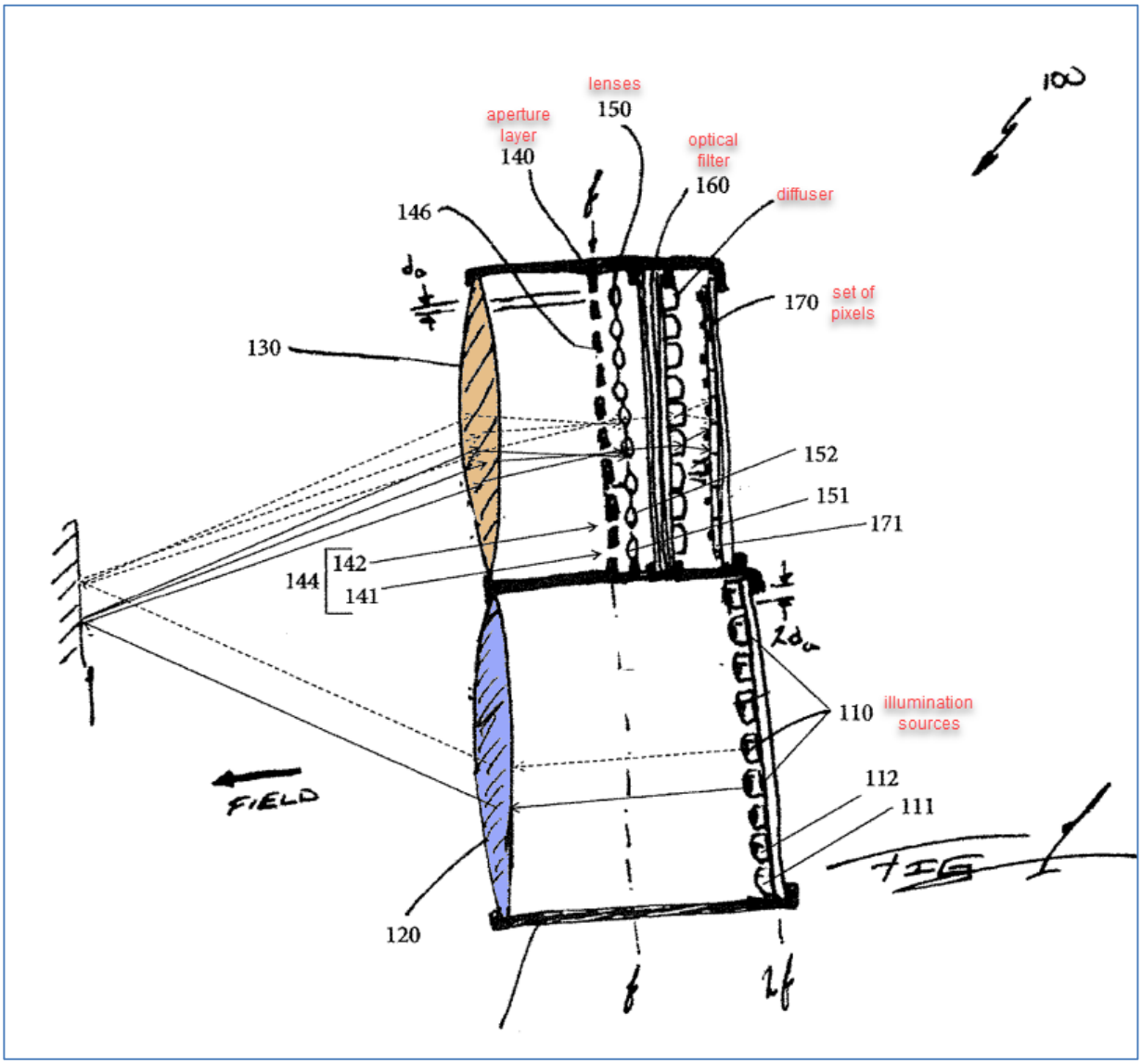
10. U.S. Patent Pub. No. 2017/0289524 ("Pacala-2017")

128. Pacala-2017 was filed on September 26, 2016, and published on October 5, 2017, more than a year before the December 4, 2018 priority date of the '515 Patent. EX1013. Thus, I understand Pacala-2017 is prior art to the '515 Patent because it was filed and published more than a year before the priority date of the '515 Patent. Pacala-2017 also claims the benefit of a provisional application filed on September 24, 2015. EX1046.

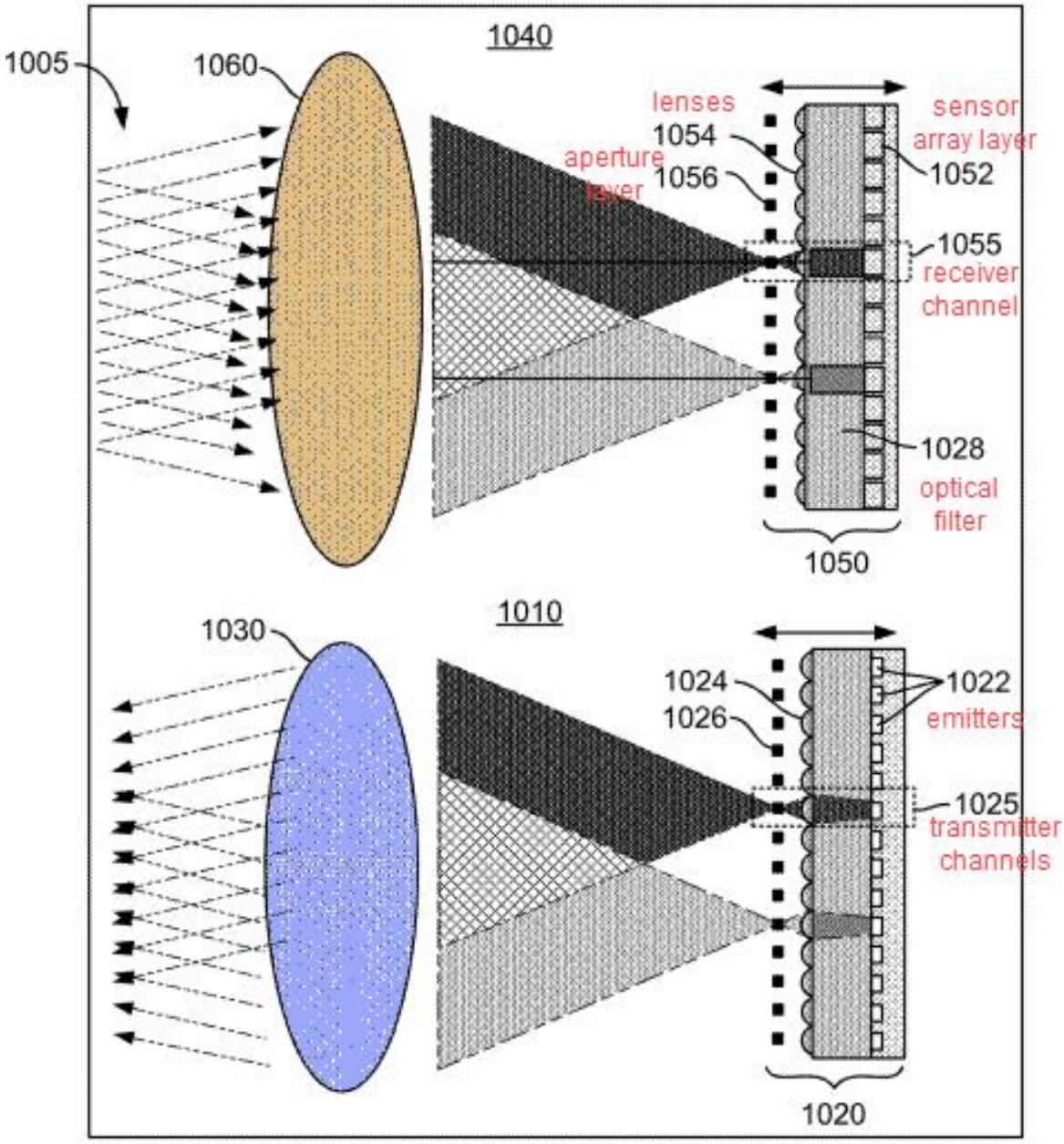
129. The Pacala-2017 reference is assigned to Ouster and names two inventors: Angus Pacala and Mark Frichtl. EX1013. Both of these inventors are also named on the '515 Patent. EX1001. As detailed below, Pacala-2017 discloses substantially the same LiDAR device as that disclosed in the '515 Patent.

130. Pacala-2017 explains that its LiDAR device (100) can be "rotated about an axis." *Id*., [0016]. The LiDAR device in Pacala-2017 is substantially similar to the LiDAR device disclosed in the '515 Patent, as can be seen below:

Pacala-2017, Fig. 1



’515 Patent, Fig. 10



Compare EX1013, [0015]-[0018], [0056], Fig. 1 (top) *with* EX1001, 36:35-39:19, Fig. 10 (bottom).

131. Pacala-2017 discloses a “bulk transmitting optic” (blue) that includes a

layer of illumination sources (110-112). EX1013, [0015]-[0016], [0044]-[0048]. It also includes a bulk imaging optic (orange) that includes an aperture layer (140), a lens layer (150), an optical filter layer (150/160), a diffuser layer (180) and a set of pixels (170). *Id*., [0019]-[0020], [0021]-[0025], [0029]-[0031], [0033]-[0036], [0037]-[0043].

132. The illumination sources and bulk transmitting optic are configured to output an illuminating beam of an operating wavelength toward a discrete spot in the field ahead of the illumination source. *Id*., [0015]-[0016]. The bulk imaging optic receives reflected light back. *Id.* Pacala-2017 explains that "each aperture in the aperture layer 140, a corresponding lens in the set of lenses 150, and a corresponding pixel in the set of pixels 170" can form a "channel." *Id*., [0018]. An aperture layer functions to define a non-overlapping field-of-view for its corresponding channel and each pixel adjacent to the optical filters corresponds to a lens, with the associated filter rejecting light outside of the operating wavelength for the channel. *Id*., Abstract, [0016], [0021]-[0023], [0025]-[0026]. Thus, each aperture defines a field-of-view in the field coincident a discrete spot output by a corresponding illumination source. *Id*., [0015], [0021].

133. Pacala is analogous art to the '515 patent because it is in the same field of endeavor, *i.e.*, structures and components for rotating ranging systems.

IX. GROUNDS

A. Ground 1 – Pacala, Johnson, Pardhan, and Zhang Render Obvious Claims 1-2, 4-9, 11, 14, 16-17 and 19.

134. In my opinion, Pacala, Johnson, Pardhan, and Zhang render obvious claims 1-2, 4-9, 11, 14, 16-17 and 19.

135. Pacala discloses the overall structure of a LiDAR system, including a LiDAR device with transmit (blue) and receive modules (orange) and an enclosure having an optically transparent window (grey):

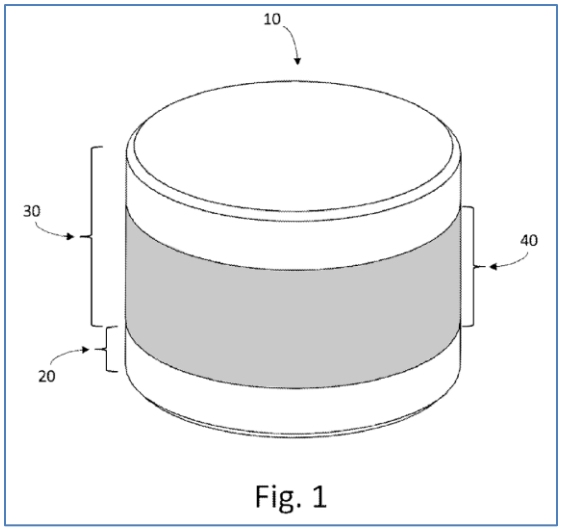


Fig. 1

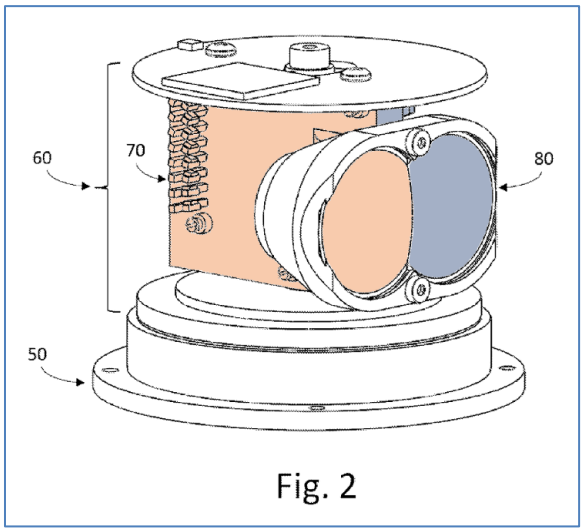
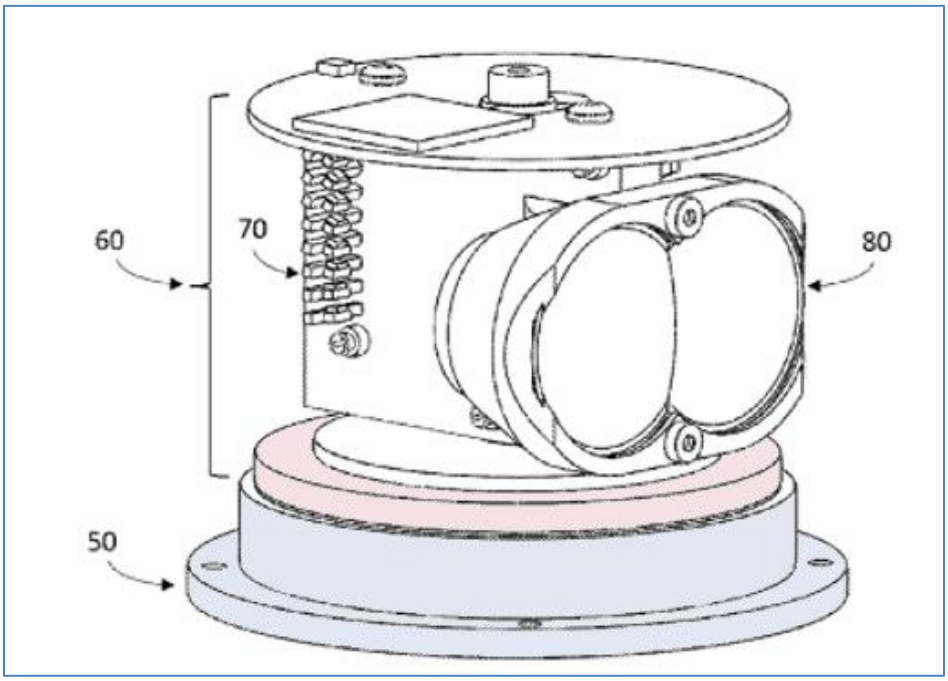


Fig. 2

EX1004, Figs. 1-2.

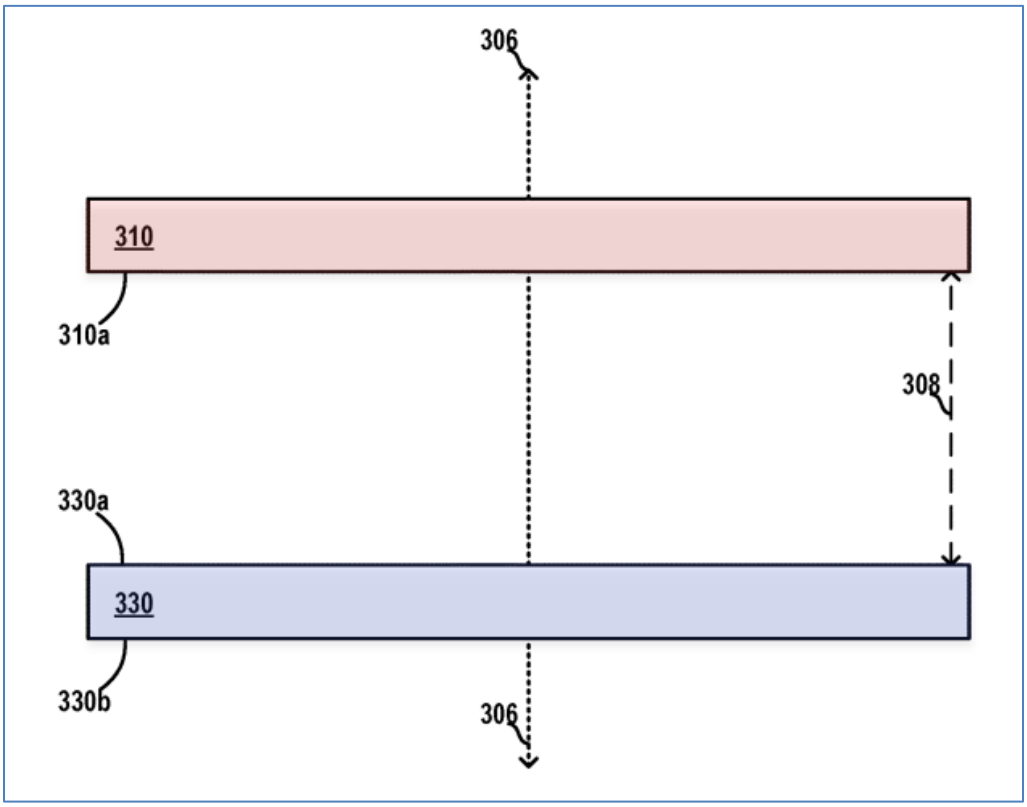
136. Pacala further discloses that the LiDAR system includes a "static base" (blue) and "spinning turret" (red) for providing rotation:



Id., Fig. 2.

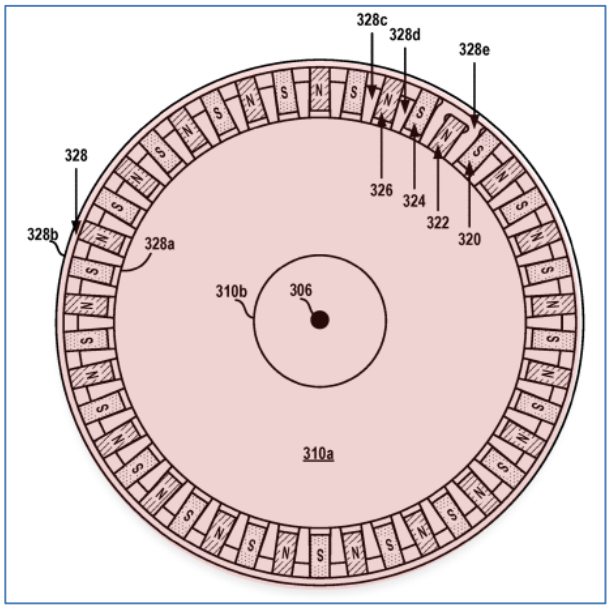
137. Pacala, however, does not detail the rotational structures of the device (*e.g.*, the arrangements of magnets, stator coils and other distributed electronics), and thus a POSITA would look to other references for implementation details.

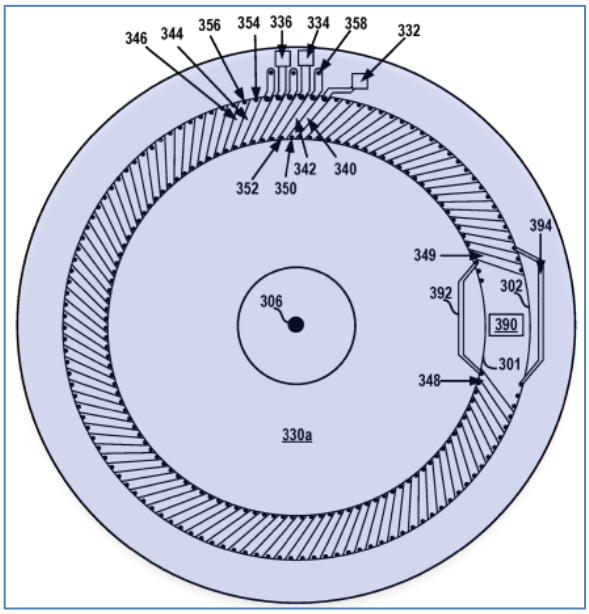
138. Johnson and Pardhan—both assigned to Waymo—teach these details. Johnson and Pardhan both disclose a rotor (red) and stator (blue) structure that can be implemented within the turret and base of Pacala:



EX1005, Fig. 3A. Like Pacala, both references teach that a LiDAR device may be mounted on top of the spinning rotor platform. *Id.*,

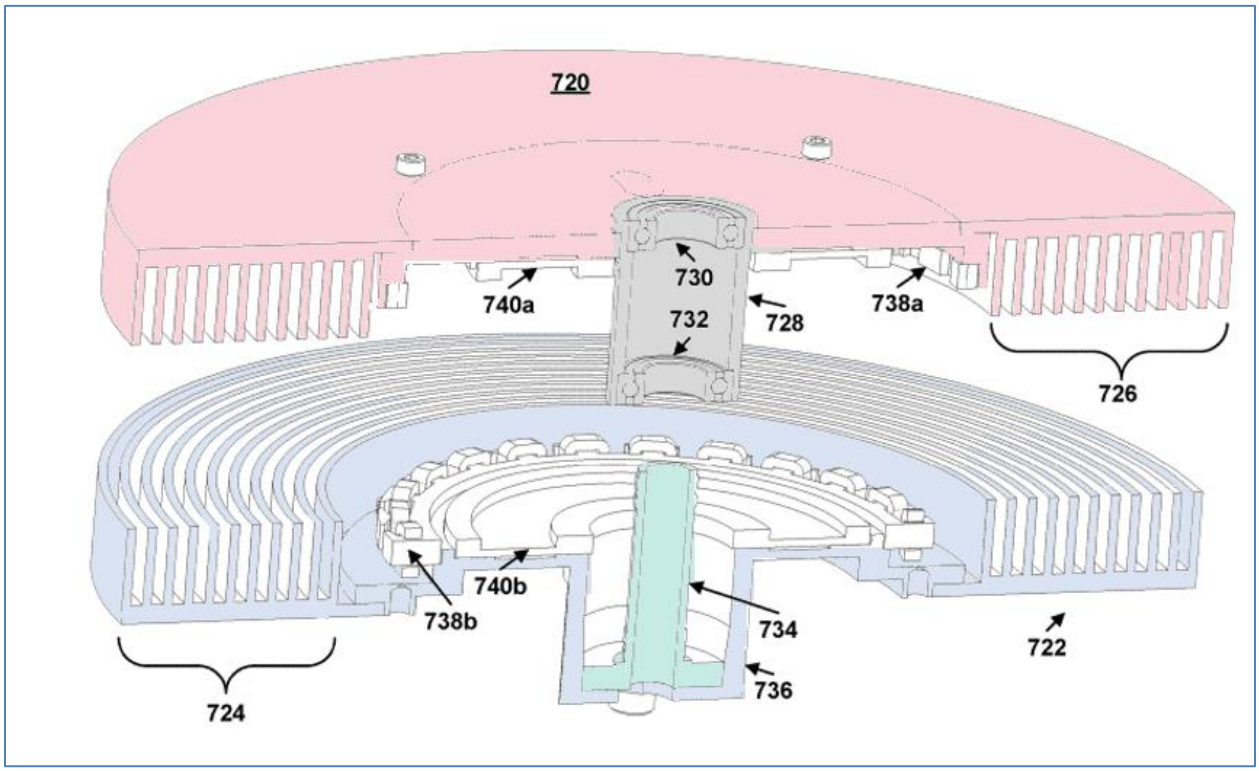
139. Johnson additionally details the arrangement of the rotor and stator elements mounted on circuit boards of the structure. For example, Figures 3B-3C (left-right) show circuit boards that are mounted on the underside of the rotor platform 310a and the upper side of the stator platform 330a:





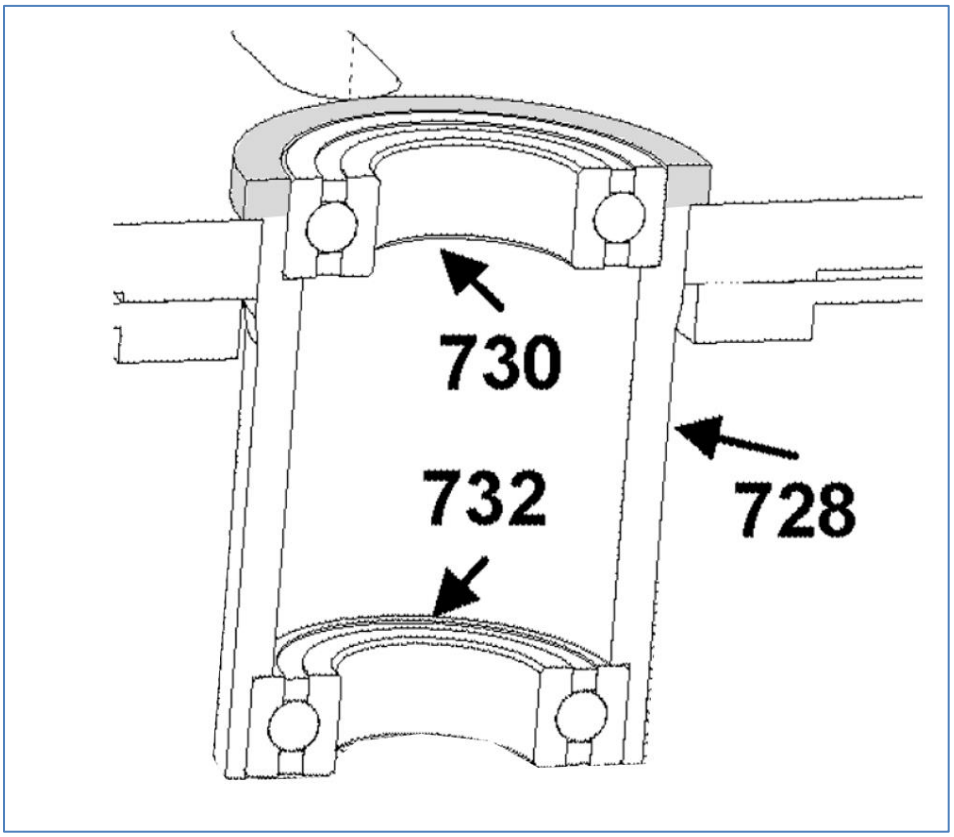
Id., Figs. 3B-C. Johnson further discloses additional electronics (*e.g.*, power interfaces, communication interfaces, *etc*.) may be included on the circuit boards of the rotor and stator platforms. *Id*., Fig. 2.

140. Johnson does not expressly disclose the details for assembling the rotating structure, however. These details are provided by Pardhan, which discloses a support component for assembling the rotating structure that comprises a sleeve fitted over a hollow shaft to support rotation via bearing 730/732:

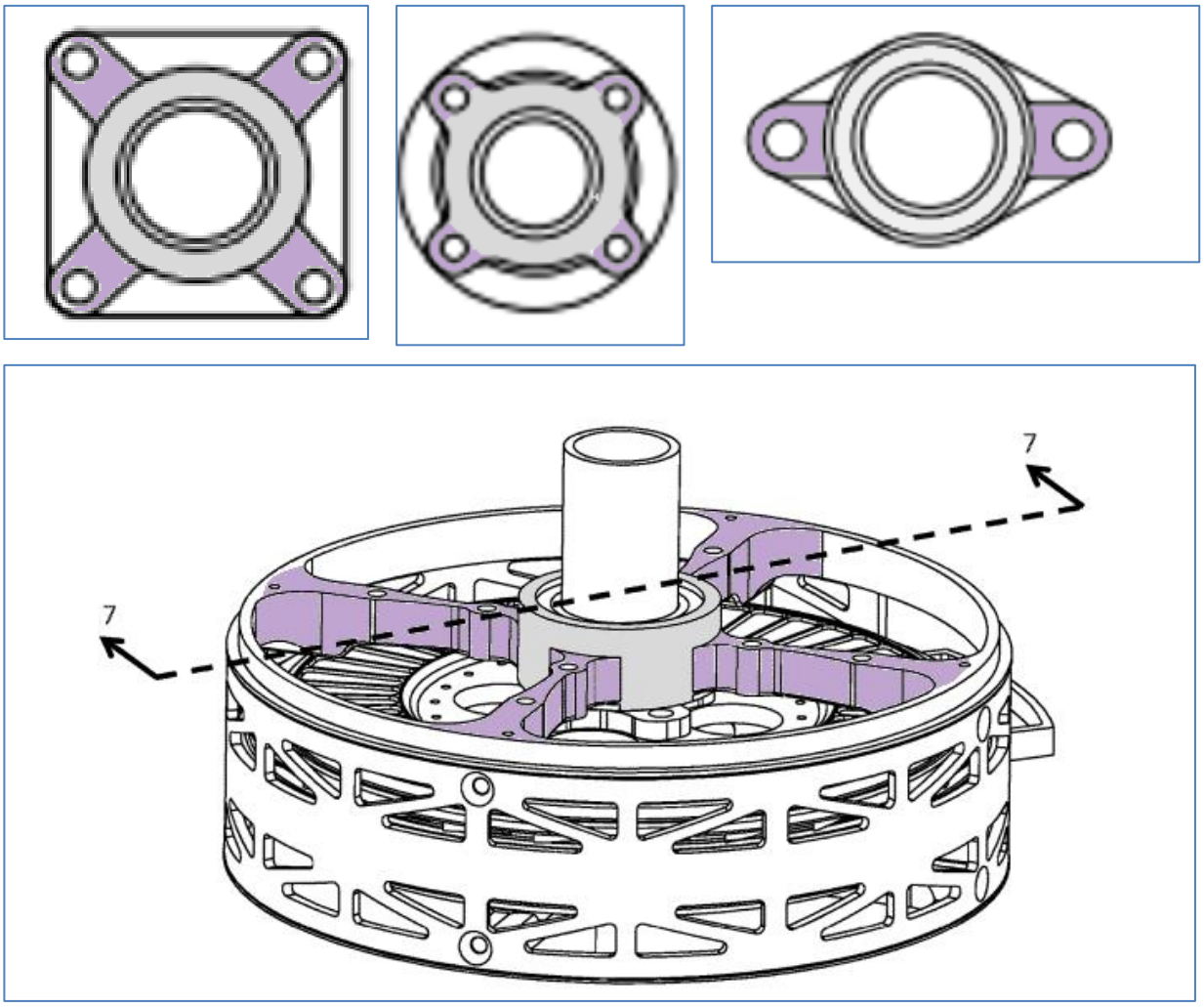


EX1006, Fig. 7B. Pardhan teaches that its support component can be made of a "metallic material with a high thermal conductivity" that transfers excess heat away from the LiDAR sensor. EX1006, 4:54-5:7, 18:6-14.

141. Although Pardhan's support component includes an upper collar (grey) that extends outwardly from the sleeve and rests on rotor plate 720 (as seen in the image below), the collar does not include arms for attaching the sleeve (which houses the bearings 730/732) to the rotor surface.

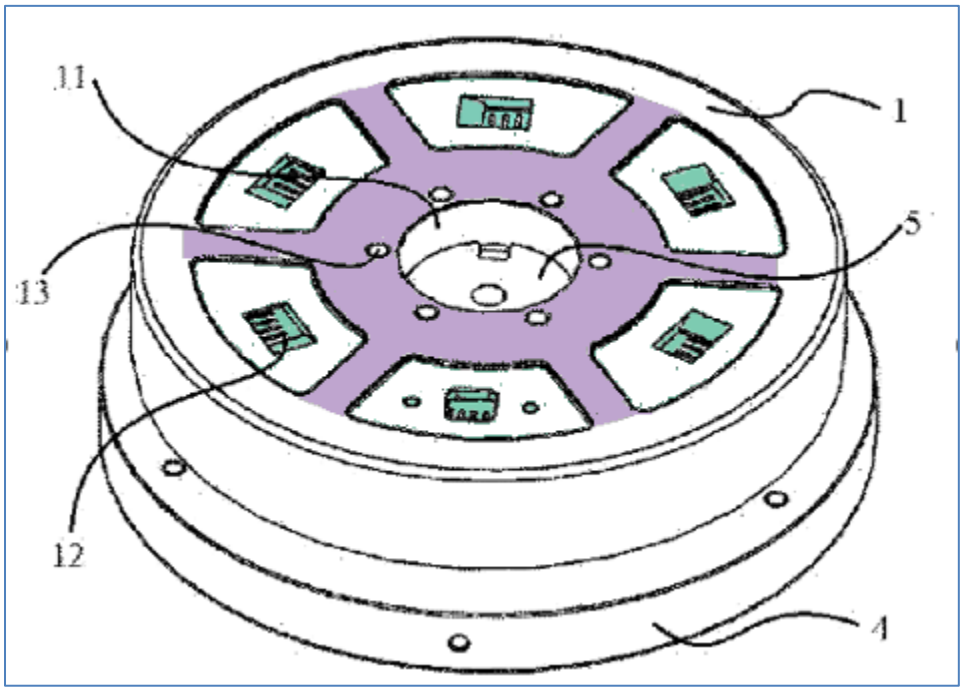


EX1006, Fig. 7B. By the priority date of the '515 Patent, it was understood that "[i]n normal motor operation, it was important for the bearing assemblies and shaft to be "held in their positions firmly." EX1031, 329-331 ("Section 6.2.5 Prevention of Bearing Axial Movement"). Accordingly, a POSITA would have understood that Pardhan's support component could be improved by utilizing one of various prior art bearing assembly designs that included arms which extend away from the sleeve and provide firm attachment to the rotor platform:



Exs. 1033, 16 (top), 1042, Fig. 6 (bottom), 6:40-47; *see also* Section VI.E.

142. Zhang also discloses a support component (shown below) that has arms (purple) extending outwards from a "hollow shaft." The support component further has heat dissipation passages (green) positioned between the arms to prevent overheating of the LiDAR device:



EX1007, Fig. 1, 6 ("at least one hollowed-out heat dissipation hole is configured on the end face of rotor."). By the priority date of the '515 Patent it was understood that spinning LiDAR devices "generate[] excess heat" that requires the rotor-stator structure to "transfer[] excess heat away from" the LiDAR device. EX1006, 4:54-5:80, 19:2-6. Thus, a POSITA would have found it particularly obvious to apply Zhang's teaching of a support component with arms and heat dissipation passages to the Pacala-Johnson-Pardhan combination to further improve the heat dissipation properties of the support component.

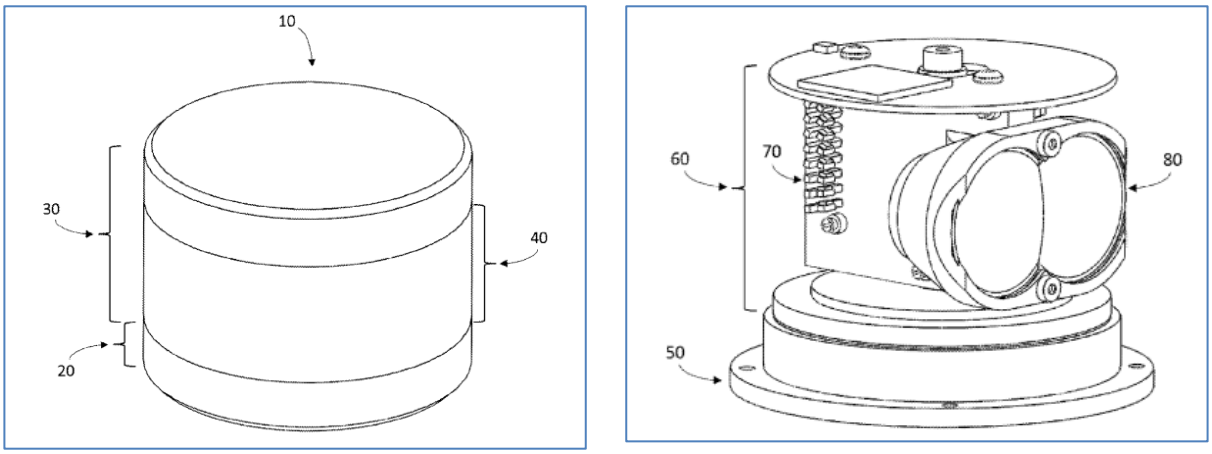
143. Below, I begin by showing how the Pacala-Johnson-Pardhan-Zhang combination renders obvious claims 1-2, 4-9, 11, 14, 16-17 and 19. Sections IX.A.1-10. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.A.12-13

1. Independent Claim 14

(a) Limitation 14[a]: A light ranging system comprising

144. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[a].

145. For example, Figures 1 and 2 show the LiDAR device (10) of Pacala:



EX1004, Fig. 1 (left) and Fig. 2 (right). The enclosure of the LiDAR sensor is shown in Figure 1. Figure 2 illustrates the LiDAR sensor mounted on the top of the spinning turret within a housing. Pacala explains that the LiDAR sensor includes a "static base" (20/50) which is the non-rotating pat of the LiDAR system. *Id.*, [0013]. It also includes a "spinning turret" (60) which is the rotating part of the LiDAR system. *Id*.

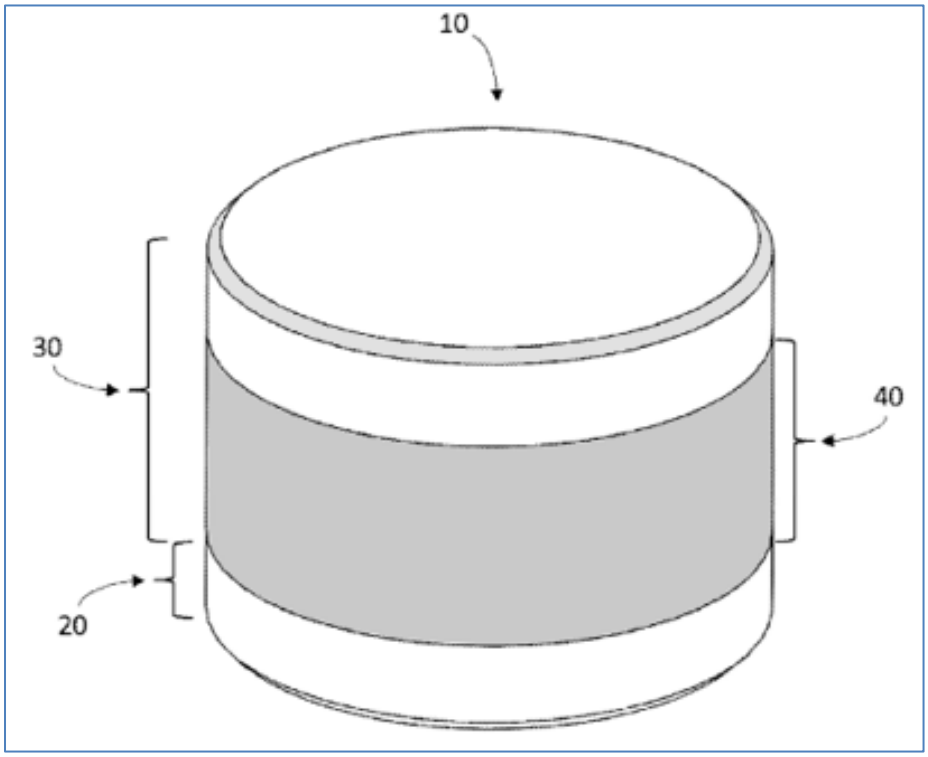
146. A POSITA would have understood that the LiDAR sensor of Pacala, including its static base and spinning turret, are a "light ranging system." Indeed, the light ranging system of the '515 Patent is also made-up of a LiDAR sensor,

spinning "turret" and static "base." EX1001, 16:12-33; *see also* Section VII.B.

(b) Limitation 14[b]*:* an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure

147. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[b].

148. The enclosure of Pacala is shown in Figure 1. It has a top and a base (20). Pacala teaches that the enclosure also includes "a window 40 that is transparent at the wavelength of the laser used in each transmitter" of the LiDAR. EX1004, [0012]. And Figure 1 shows the optically transparent window disposed between a base and a top cover (grey):



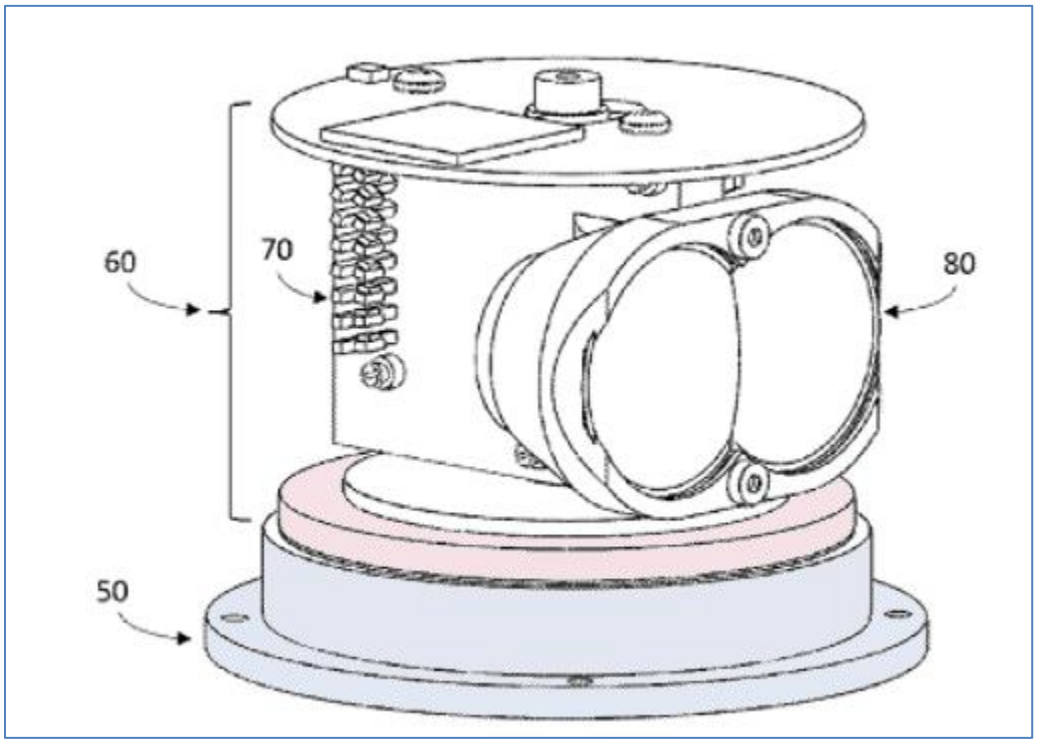
EX1004, Fig. 1.

149. A POSITA would have understood that window 40 extends fully around a periphery of the enclosure because Pacala teaches that its "head assembly 30" is "static," while its LiDAR sensor is "spinning." EX1004, [0012]-[0013]. Thus, a POSITA would have understood that the window must be optically transparent around the entire enclosure for the transmitters and receivers within the enclosure to transmit and receive light.

(c) Limitation 14[c]: a shaft disposed within the enclosure and defining an axis of rotation

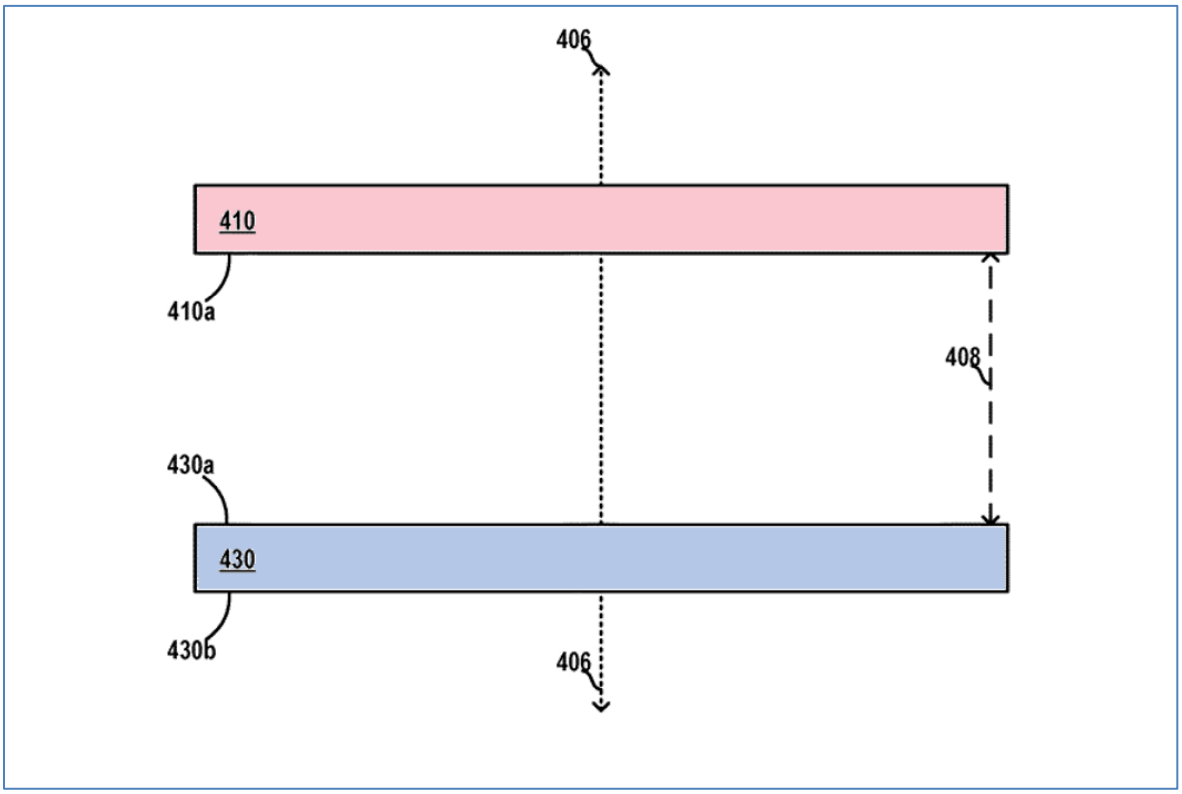
150. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[c].

151. As I discussed in connection with Limitation 14[b], Pacala's LiDAR device includes a spinning turret and a static base within the enclosure. *See also* EX1004, [0012]-[0013], Figs. 1-2. The LiDAR device is mounted to a platform of the spinning turret (red), which is above the static base (blue), as shown in Figure 2:



EX1004, Fig. 2. However, Pacala does not provide the implementation details of these structures. Thus, a POSITA would look to other references that describe how to implement a rotating platform with a static base, such as Johnson.

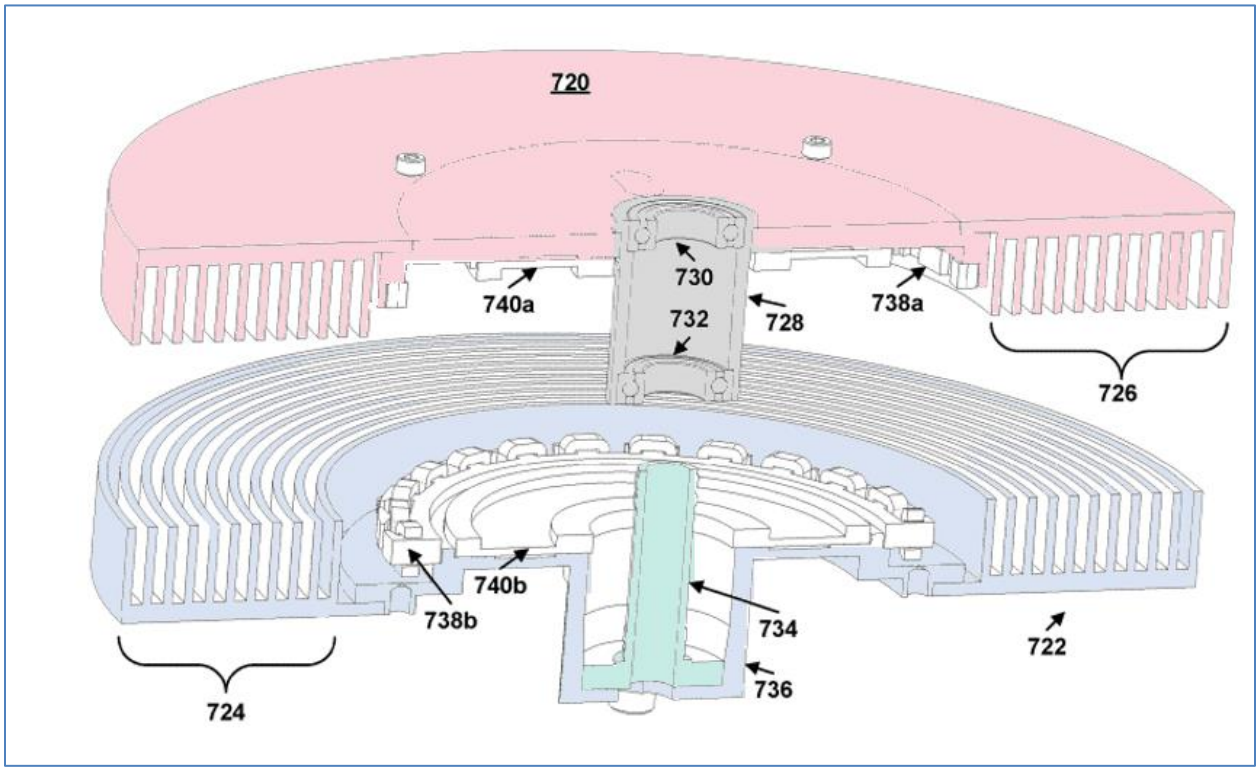
152. Johnson teaches a rotor-stator structure that can be implemented within the turret and base of Pacala, such that it would be within the enclosure of Pacala that is shown in Figure 1. For instance, Figure 3A of Johnson (reproduced below) shows a rotor platform 310 (red) that rotates about a stationary stator platform 330 (blue) about axis of rotation 306:



EX1005, Fig. 3A; 16:57-17:3. Johnson's design is particularly well-suited for Pacala because it integrates the "PCB motor" directly onto the rotor-stator structure to provide a "a more compact design and/or efficient use of space." *See* EX1045, 4:1-6 (Waymo patent illustrating rotor-stator structure similar to Johnson). Thus, a POSITA would have implemented the rotating platform 310 as part of the spinning turret platform of Pacala, while the stator platform 330 would have been implemented as part of the static base of Pacala. A POSITA would also understand that the dotted line representing the axis of rotation 306 is a shaft within the enclosure that defines the axis of rotation, and that the rotor platform rotates about this shaft.

153. Although a POSITA would have understood that Johnson discloses a shaft defining the axis of rotation 306, Johnson does not provide details relating to the shaft or the structures used to provide attachment and rotation of the rotor-stator structure. Thus, a POSITA would have looked to Pardhan—another patent from Waymo—that describes these details.

154. Figure 7B of Pardhan also discloses a rotor-stator structure for LiDAR applications. A stator plate (blue) is coupled to a hollow shaft 734 (green) that extends upward along the vertical axis of rotation, and a rotor plate (red) is coupled to a hollow sleeve 728 (grey) that fits over the hollow shaft and rotates about the shaft via bearings 730 and 732:



EX1006, 20:40-63, 21:42-45, Fig. 7B. The rotor plate 720 (along with its fins) may

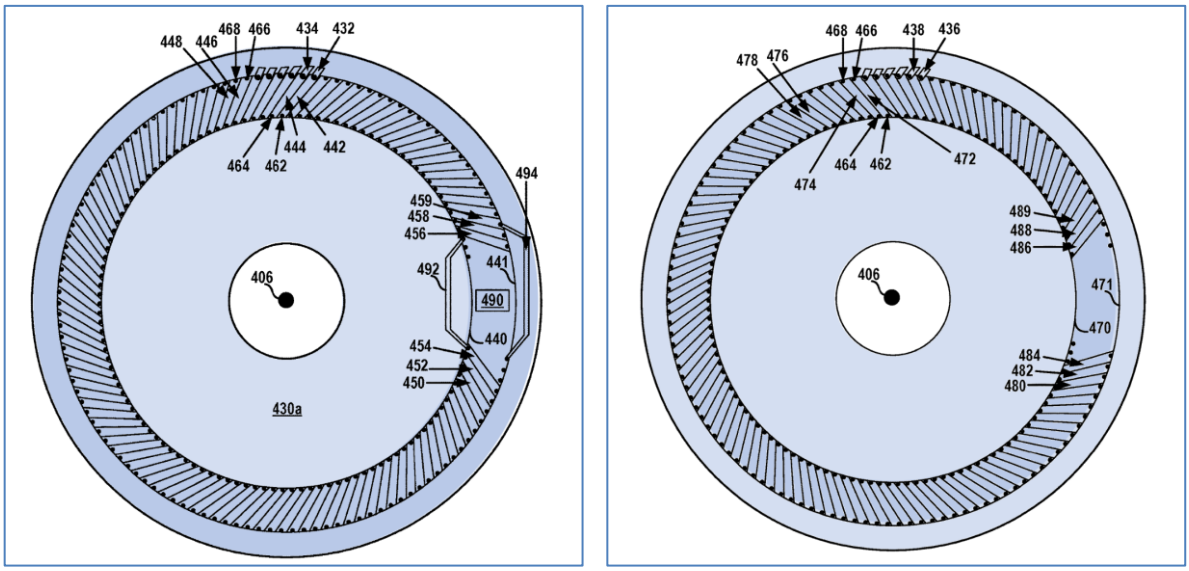
be manufactured as "one piece" that is made from a "metallic material with high thermal conductivity" so as to transfer heat away from the LiDAR device. *Id.*, 18:6-19.

155. Applying the teachings of Johnson and Pardhan to Pacala, a hollow shaft would extend vertically upward from the stator plate to the rotor plate (as disclosed in Pardhan) and that shaft would define the axis of rotation for the light ranging system. The resulting rotor-stator structure would continue to be implemented within the enclosure of Pacala and the light ranging device of Pacala would continue to rotate about the axis of rotation. *See* EX1006, Fig. 7A.

(d) Limitation 14[d]: a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure

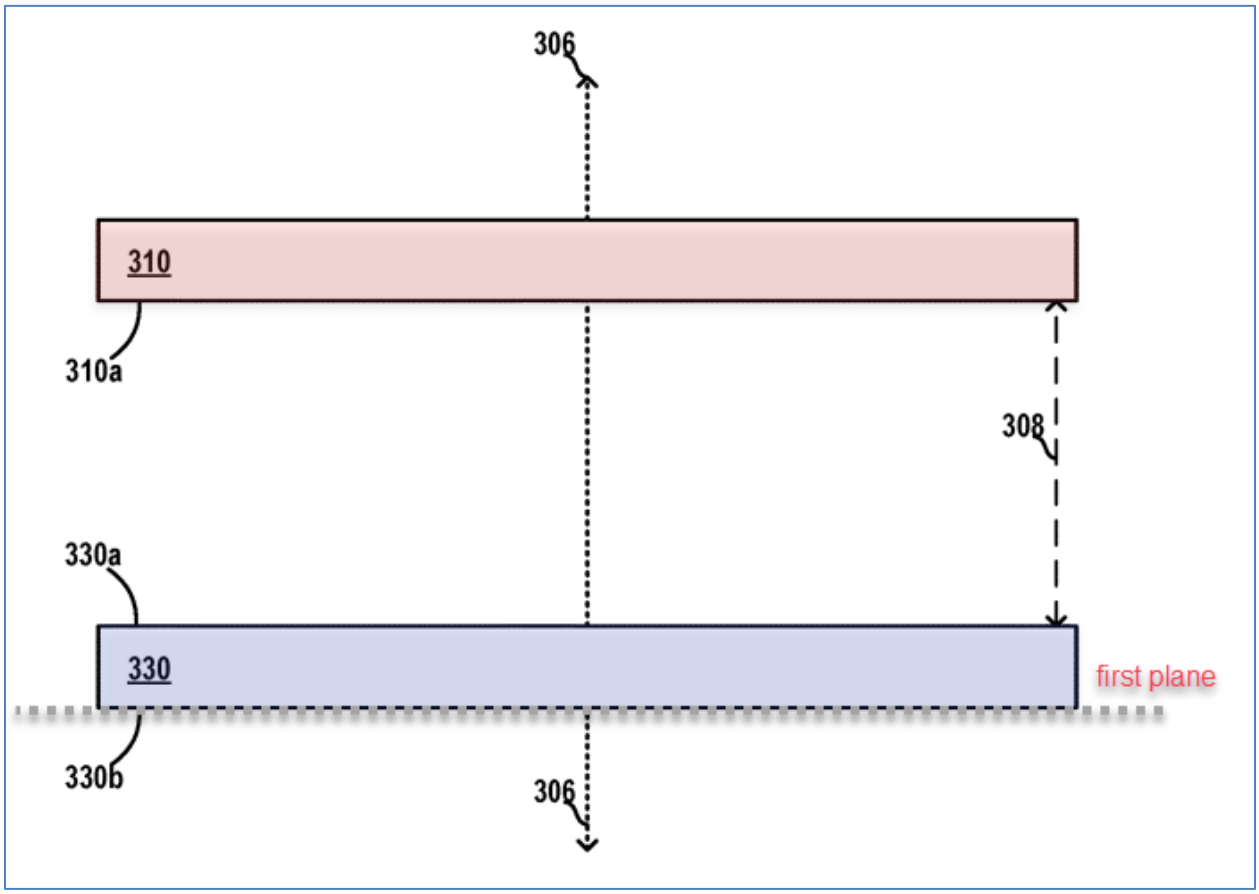
156. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[d].

157. Johnson discloses the claimed stator circuit board. For instance, stator platform 330 may comprise a "planar mounting surface" that is implemented as "a multi-layer circuit board (e.g., PCB) or may comprise a multi-layer PCB." EX1005, Abstract, 10:57-63, 11:66-12:17, Fig. 3A. Figures 3C and 3D illustrate two layers of a multi-layer PCB of the stator platform 330:



EX1005, Figs. 3C-3D, 11:66-12:18. The upper layer (Figure 3C) may be disposed along top side 330a of the stator platform, while the lower layer (Figure 3D) may be "substantially parallel to side 330a," *e.g.*, "between sides 330a [top] and 330b [bottom]." *Id*. Johnson also teaches that a layer may be disposed along bottom side 330b. *Id*.

158. The stator circuit board is disposed along a plane perpendicular to the axis of rotation. For instance, the stator platform may include parallel circuit board layers along the top and bottom sides (330a and 330b), such that each layer is along a plane perpendicular to the axis of rotation 306:



EX1005, Fig. 3A, 10:48-62. The stator platform includes a multi-layer circuit board, as discussed in connection with Limitation 14[d]. A POSITA would have understood that each of the layers in the multi-layer circuit board of the stator platform are perpendicular to the axis of rotation. Thus, for example, the lower-most layer would be a first plane perpendicular to the axis of rotation 306 and the stator circuit board would be disposed along that first plane.

159. A POSITA would also understand or find it obvious to fixedly couple the stator circuit board to the base of Pacala's enclosure. As I discussed above in connection with limitation 14[c], a POSITA would implement Johnson's stator

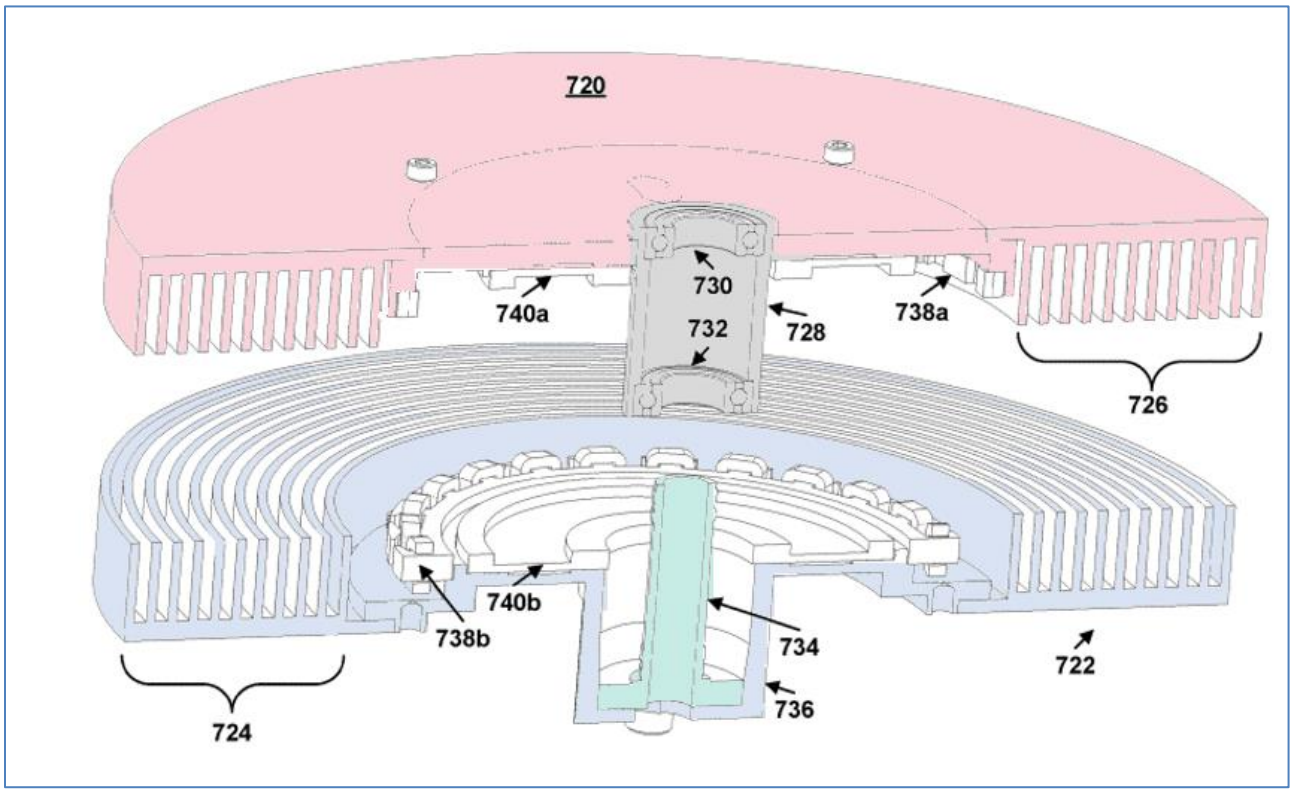
platform within the static base of Pacala. Johnson further teaches that its stator platform is fixed relative to rotation of the rotor platform, and is the lower most layer of the device. EX1005, Figs. 2-3A. Thus, a POSITA would have understood that the base of the enclosure in Pacala, which is also the lower most layer of the device, is a logical place to mount the stator platform and circuit board. This teaching is reinforced by Pardhan, which illustrates the stator platform mounted to the base of a light ranging system within an enclosure. EX1006, Figs. 7A-7B.

(e) Limitation 14[e]: a support component comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve

160. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[e].

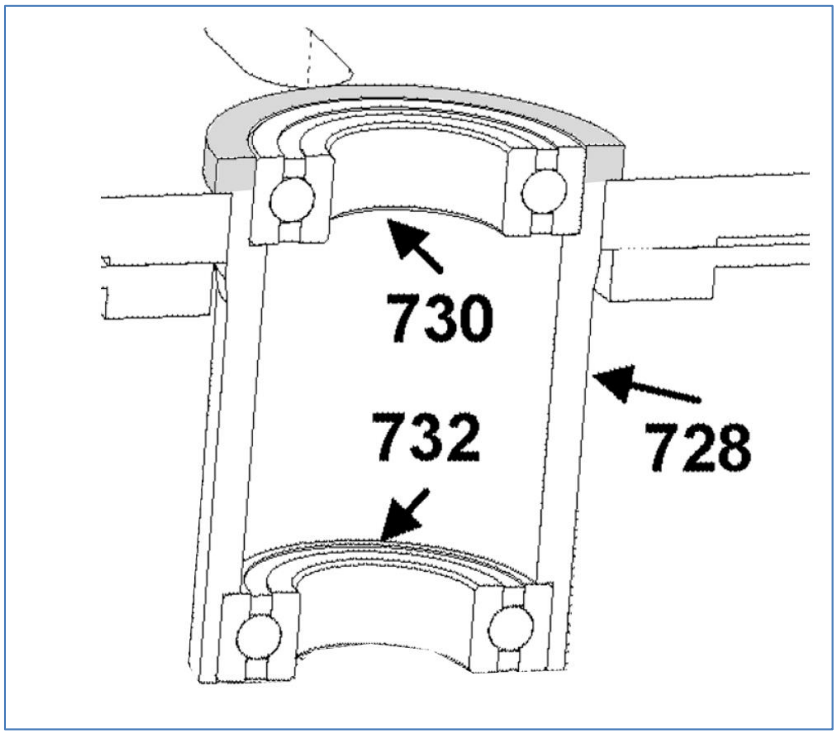
161. I understand that in the ITC action the parties proposed constructions of the term "sleeve," which appears in this limitation. I understand that no construction was adopted by the ITC. I understand that the ITC Staff proposed that the term "sleeve" should be given its "plain and ordinary meaning, for example a tube that encloses a shaft." EX1020. I understand that Ouster proposed that the term "sleeve" does not need a construction. EX1021. And I understand that Hesai proposed that the term "sleeve" be construed as a "cylindrical tube." EX1022. The prior art I discuss below discloses a sleeve that is a "cylindrical tube" which "encloses a shaft," such that it would satisfy all of these constructions.

162. Figure 7B of Pardhan shows a support component that comprises a rotor plate (red) and sleeve (grey), where the sleeve is fitted over a shaft (green) on the stator plate (blue). As can be seen the, the sleeve in Pardhan is a cylindrical tube.



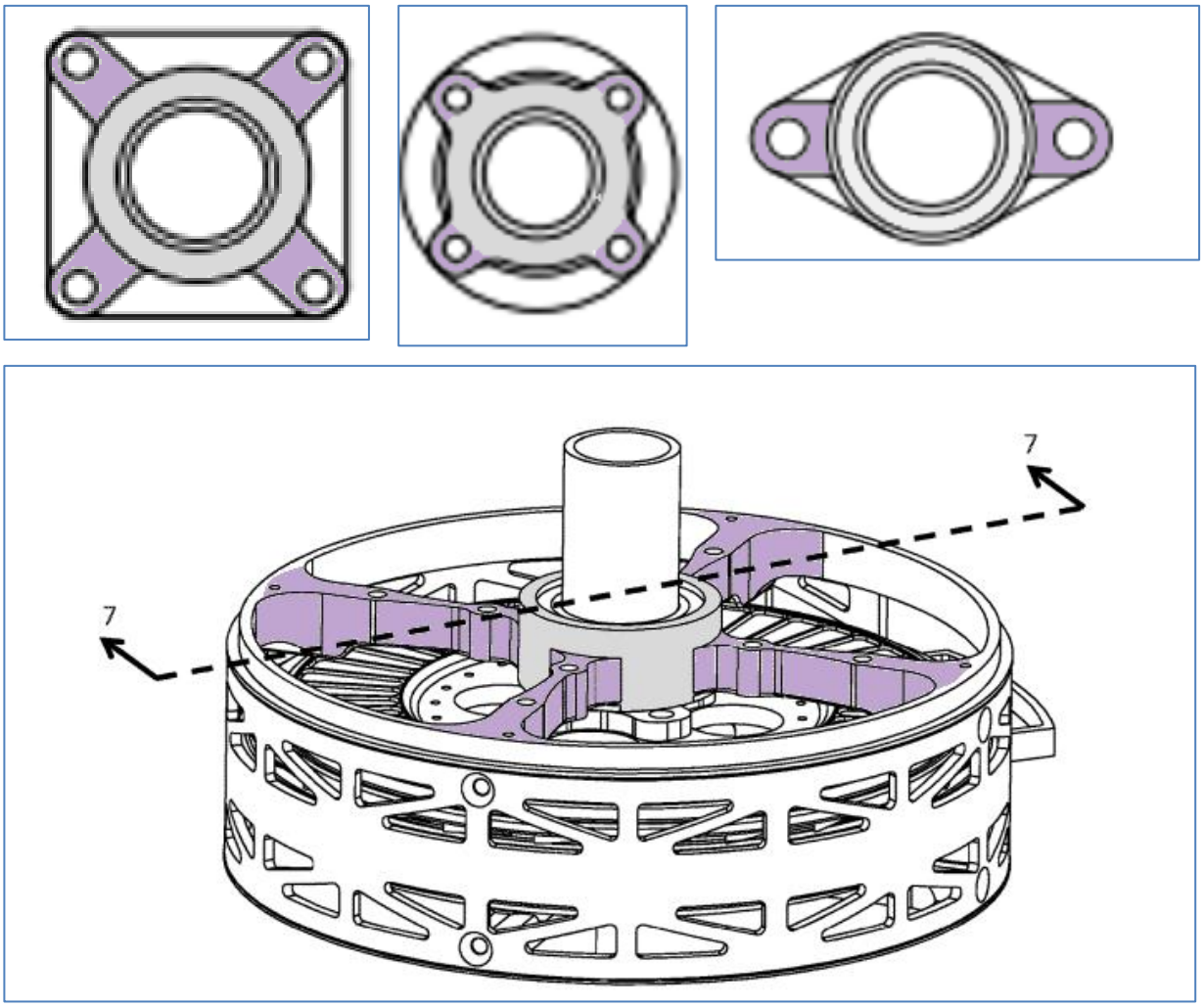
EX1006, Fig. 7B, 20:64-21:14.

163. As illustrated below, the sleeve of Pardhan's support component includes an upper collar (grey) that rests on the rotor plate 720, although that support component does not include arms extending away from the sleeve:



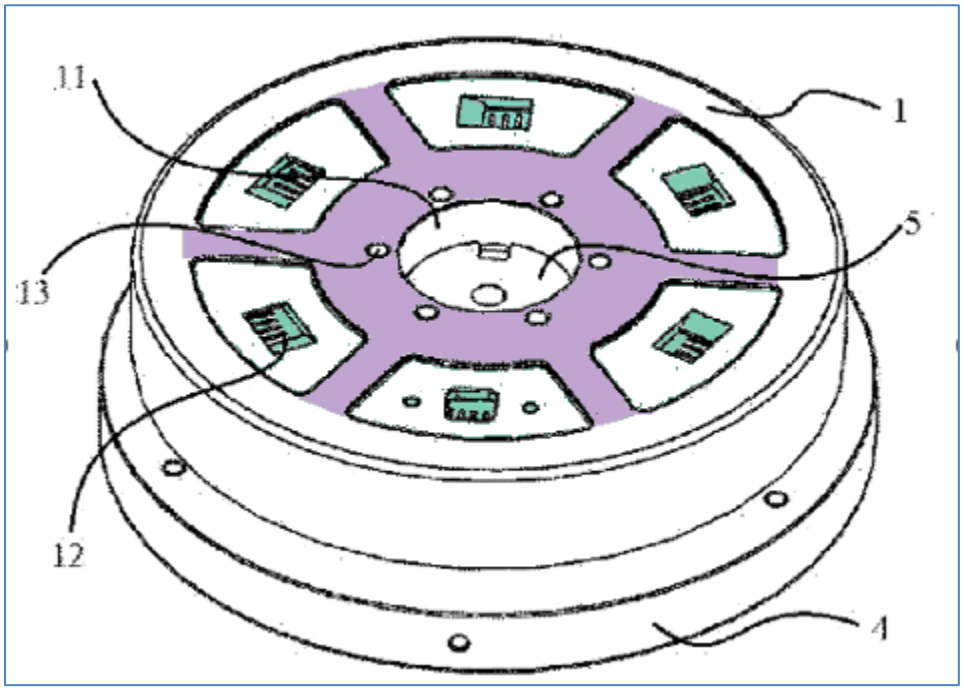
EX1006, Fig. 7B. In my opinion, however, a POSITA would have found it obvious to modify Pardhan's support component to include arms extending away from the sleeve, as claimed in Limitation 14[e].

164. First, it is my opinion that this modification was obvious in view of the knowledge of a POSITA at the time of the '515 Patent's priority date. The support component in Pardhan provides a housing for the bearings 730 and 732. *Id*.; EX1006, 20:40-63. As I explained in Section VI.E, numerous bearing housing designs were known by the priority date and commonly used in rotor-stator structures, such as those shown below:



Exs. 1033, 16 (top), 1042, Fig. 6 (bottom), 6:40-47. A POSITA would have understood that different bearing housing designs can be interchangeably used with Pardhan's support component. For instance, the designs above include arms (purple) that extend away from a circular collar (grey). A POSITA would have found it straightforward to modify Pardhan in view of these designs, such that Pardhan's support component would include arms for coupling the sleeve to the rotor platform, thereby strengthening the attachment of the sleeve (and the bearings it houses) to the rotor plate.

165. Second, modifying Pardhan to include arms was also obvious in view of Zhang. Figure 1 of Zhang shows a rotating structure for a laser radar that includes a support component with arms that extend outwards from a "hollow shaft," and heat dissipation passages that are disposed between each arm (green):



EX1007, Fig. 1; *see also id.*, pg. 6 ("Preferably, at least one hollowed-out heat dissipation hole is configured on the end face of rotor."). Pardhan's rotor 720 is already shown as being a circular surface and thus it would have been straightforward to implement Zhang's support structure on the rotor 720 of Pardhan. The resulting structure would continue to include sleeve 728 that fits over shaft 734, and its bearings 730/732, but would further include arms on the upper surface of the support component and heat dissipation passages, as taught in Zhang, for providing further heat dissipation to prevent overheating.

166. I discuss further motivations to combine and show that there is a reasonable expectation of success in making this modification below. *See* Sections IX.A.12-13.

(f) Limitation 14[f]: one or more bearings coupled between the shaft and the support component allowing the support component to rotate around the axis of rotation

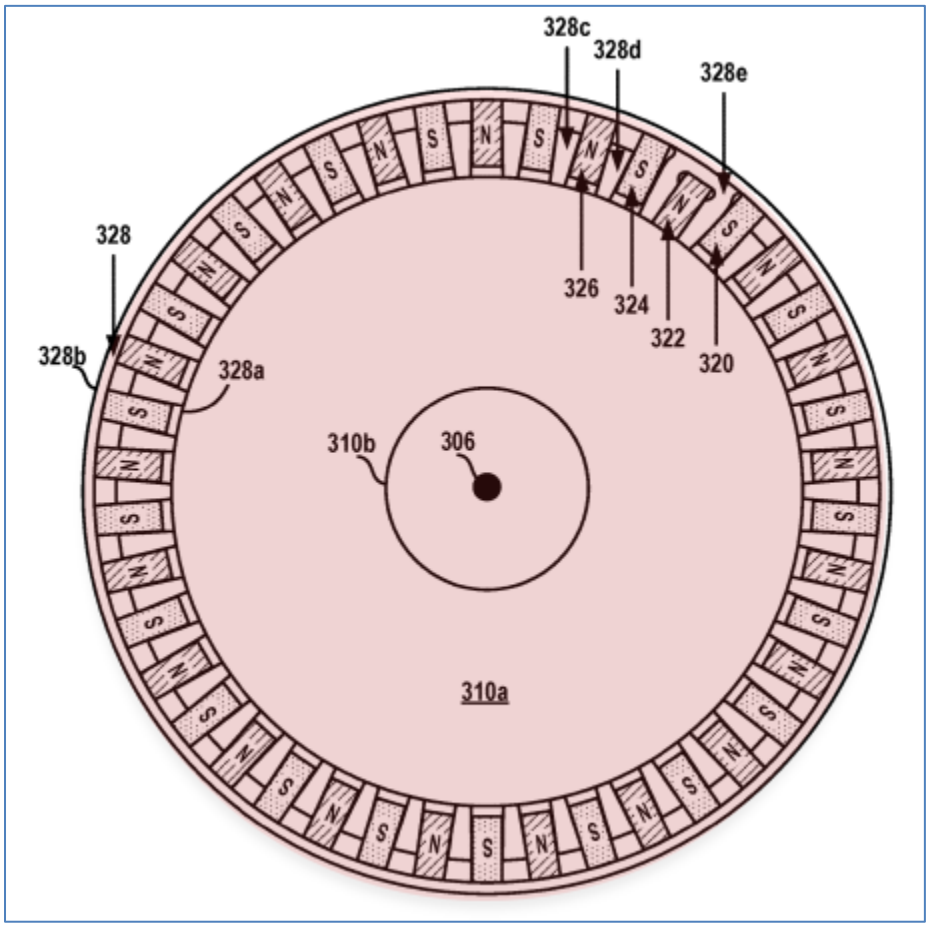
167. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[f].

168. As I discussed in connection with Limitation 14[e], Pardhan's support component includes bearings 730 and 732. The bearings are coupled between the shaft and allow the support component to rotate about the shaft 734 that defines the axis of rotation. EX1006, 20:51-64, Fig. 7B.

(g) Limitation 14[g]: a rotor circuit board coupled to rotate with the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover

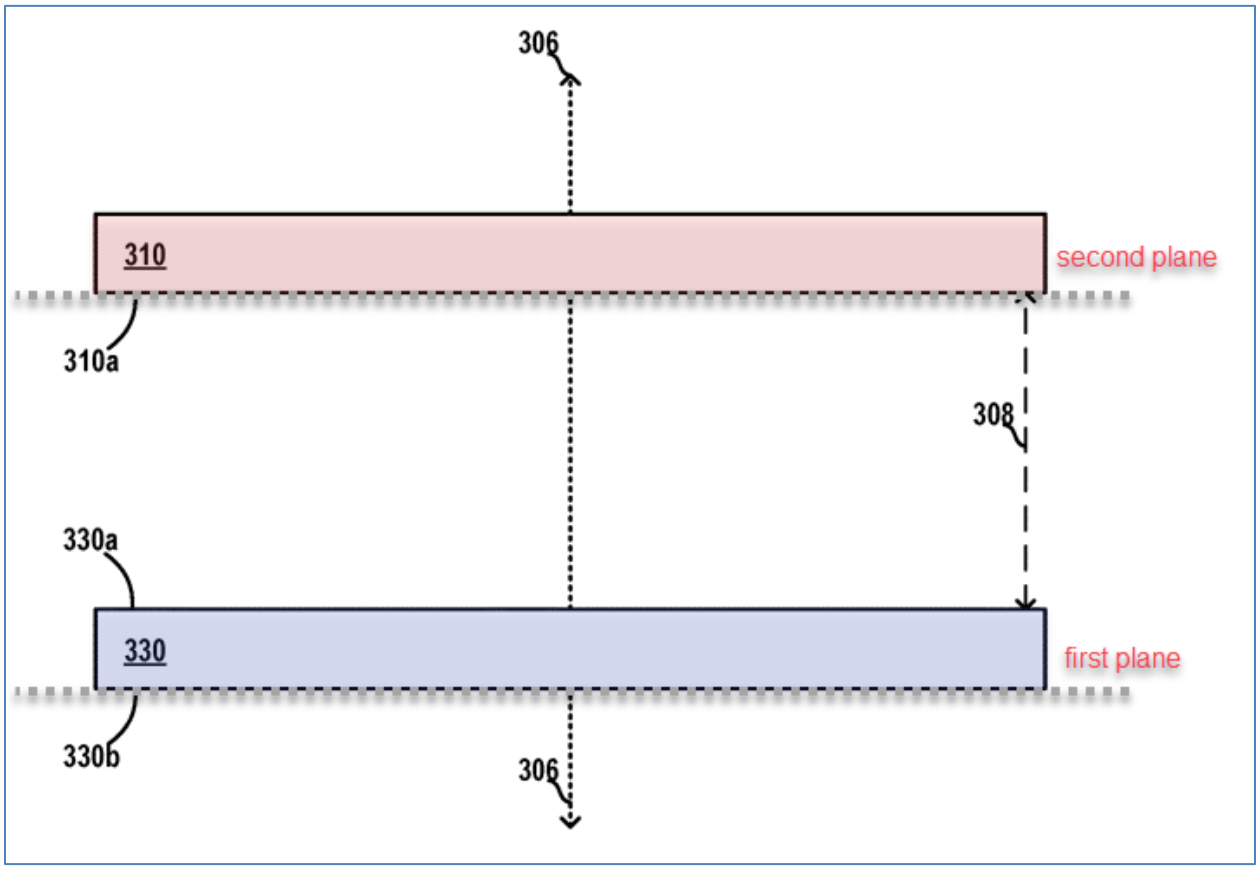
169. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[g].

170. Johnson discloses a rotor circuit board. For instance, Johnson states that its rotor platform 310 includes a "planar mounting surface" where "side 310a" (red) is an "outer layer of a circuit board," as shown in Figure 3B:



EX1005, Fig. 3B, 10:58-11:65.

171. Johnson also discloses that the rotor circuit board is disposed along a second plane parallel to the first plane. I showed in connection with Limitation 14[d], that the stator circuit board is disclosed along a first plane of the stator platform 330. Figure 3A of Johnson further shows that side 310a that includes the rotor circuit board is along a second plane that is parallel to the first plane:

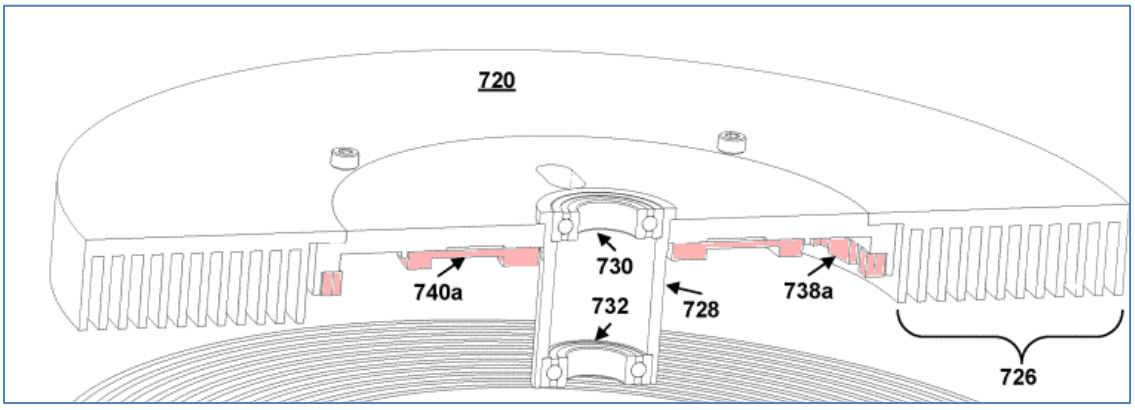


EX1005, Fig. 3A, 10:47-63.

172. A POSITA would have also found it obvious to couple the rotor circuit board of Johnson to the bottom surface of the support component in the Pacala-Johnson-Pardhan-Zhang combination, such that it would rotate with the support component. Johnson explains that its rotor circuit board is designed to "rotate[] about the axis of rotation 306" (EX1005, 10:47-63) and Pardhan teaches that its support component rotates about the shaft 734 that defines the axis of rotation (EX1006, 20:54-56).

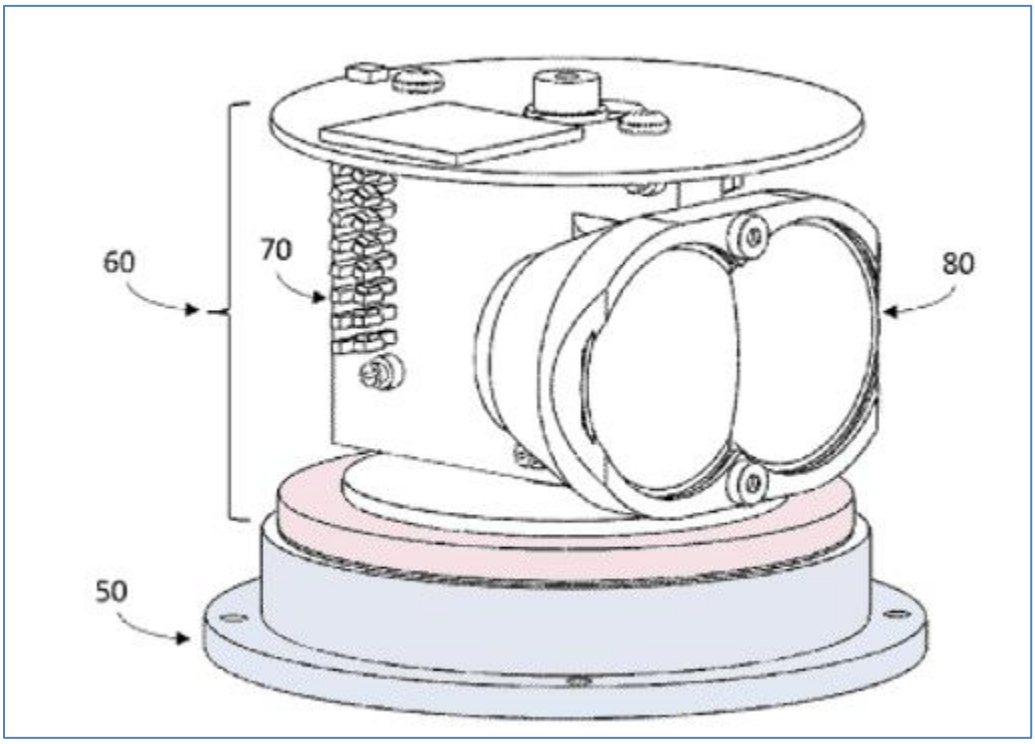
173. Further, the prior art includes express teachings that would motivate a

POSITA to combine the references in this manner. A POSITA would have been motivated to implement Pardhan's support component with Johnson's rotor circuit board because the support component can be made of a "metallic material with a high thermal conductivity" that transfers excess heat away from the LiDAR sensor, thereby allowing the device to avoiding overheating. EX1006, 4:54-5:7, 18:6-14. The prior art further teaches that in the combined system Johnson's rotor circuit board should be positioned on the underside of Pardhan's support component. For instance, Johnson states that the components of its system "may be implemented… in any suitable combination and location" (EX1005, 19:66-20:4), and implementing the rotor circuit board on the underside of Pardhan's support component is a suitable (and desirable) location because it allows the motor magnets and transformer coils to face the motor coils and transformer coils on the stator circuit board with which they interact for efficient operation. In fact, Pardhan itself teaches that the rotor elements (*e.g.*, magnets 738a and transform windings 740a) should be positioned in this arrangement:



EX1006, 17:15-18, 21:52-57, Fig. 7B. Thus, mounting the rotor circuit board of Johnson—which also includes magnets and transformer coils (EX1005, 17:10-30, 18:8-24, Fig. 3B)—to the bottom surface of the support structure would be a natural fit and would result in Pardhan's support component continuing to include the magnets and transformer coils in the same position. And Although Pardhan mounts the rotor elements directly to the rotor plate, a POSITA would have understood that utilizing an intermediary circuit board, as taught in Johnson, was desirable because the various electronic components of the rotor would benefit from simplified electrical connections, reduced electronic noise, and a more compact design when a circuit board is utilized. Additional reasons to combine are discussed in Sections IX.A.12-13.

174. Finally, as I discussed in connection with Limitation 1[c], the support component and rotor circuit board in the combined system would be implemented within the spinning turret (red) of Pacala:



EX1004, Fig. 2. The LiDAR device would be further mounted above the support component, such that the top of Pacala's enclosure is the highest point of the device. Thus, in the combined Pacala-Johnson-Pardhan system, the rotor circuit board (within the spinning turret) would be disposed along a second plane that is between the first plane (defined by the stator platform in the base) and the top of the enclosure. This teaching is also reinforced by Pardhan, which similarly confirms that the light ranging device is mounted on the rotor platform (EX1006, 16:51-64, Fig. 4; EX1005, Fig. 2).

(h) Limitation 14[h]: a stator assembly coupled to the stator circuit board and comprising a plurality of stator elements arranged annularly about the axis of

rotation, each of the plurality of stator elements including a coil

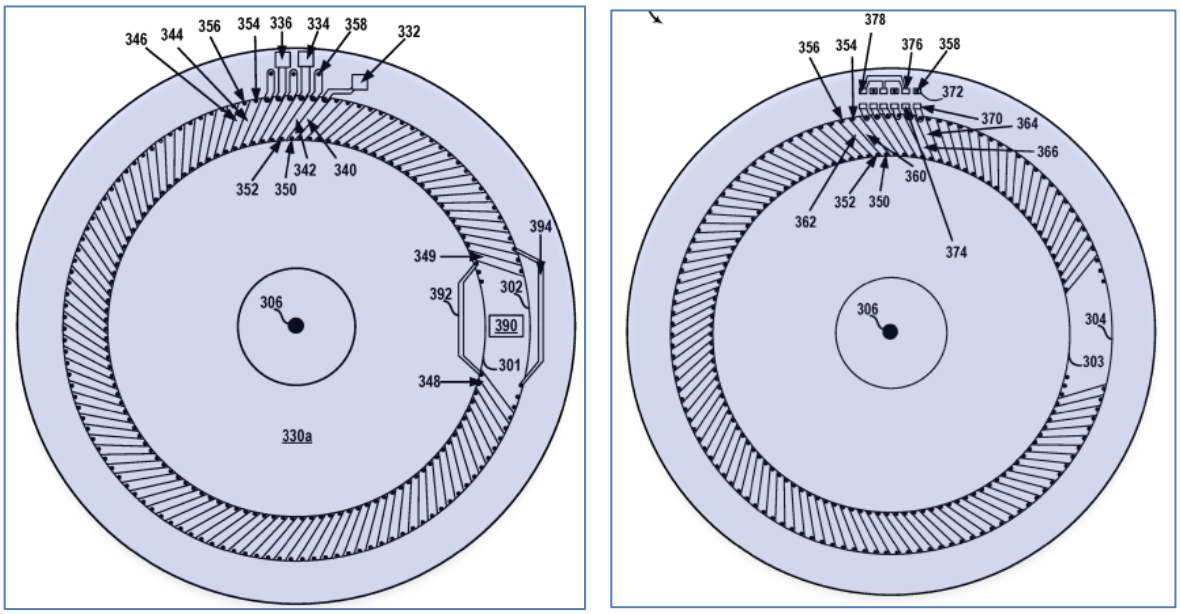
175. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[h].

176. I understand that in the ITC action the parties proposed constructions of the term "stator assembly coupled to the stator circuit board," which appears in this limitation. I understand that no construction has been adopted by the ITC. I understand that the ITC Staff proposed that the term should be given its "plain and ordinary" meaning. EX1020. I understand that Ouster proposed that the plain and ordinary meaning allows the stator assembly to be "directly or indirectly connected" to the stator circuit board. EX1021. I further understand that Hesai has proposed that the term should be construed to require that the stator assembly be "attached or mounted directly to the stator circuit board." EX1022. Because Johnson discloses that the stator assembly is directly mounted to the stator circuit board, it is my opinion that this limitation is met under all of these constructions.

177. Initially, as I discussed in connection with Limitation 14[d], Johnson includes a stator circuit board.

178. Johnson also includes a stator assembly that is coupled to the stator circuit board and comprises a plurality of stator elements arranged annularly about the rotation axis. For instance, Figures 3C-3D are layers of Johnson's stator circuit

board that include "conductive structures" (e.g., 340) "in a circular arrangement around axis 306," contacts (*e.g.*, 332), interconnects (e.g., 350) and a hall sensor (390):



EX1005, Figs. 3C-3D, 11:66-12:13, 3:40-64. The stator elements are "mounted to" the stator circuit board (*id.*, 15:34-42, 11:66-12:18, 8:62-68), such that they are "coupled to" the stator circuit board under any party's proposed construction.

179. Johnson also explains that each stator element includes a coil. For instance, the conductive structures may be "coupled to one another to form a plurality of coil windings" around axis 306. EX1005, 13:14-50, 4:56-5:8. For example, "a first coil winding" may comprise "structure 340, interconnect 350, structure 360, interconnect 354, structure 344, etc., through structure 364" and a "second coil winding" may comprise "structure 342, interconnect 352, structure 362,

interconnect 356, structure 346, etc., through structure 366." *Id*., 13:26-40.

180. Thus, a POSITA would have understood that each current-carrying coil arranged annularly around the axis in Johnson (from lead-to-lead) is a claimed stator element that includes a coil.

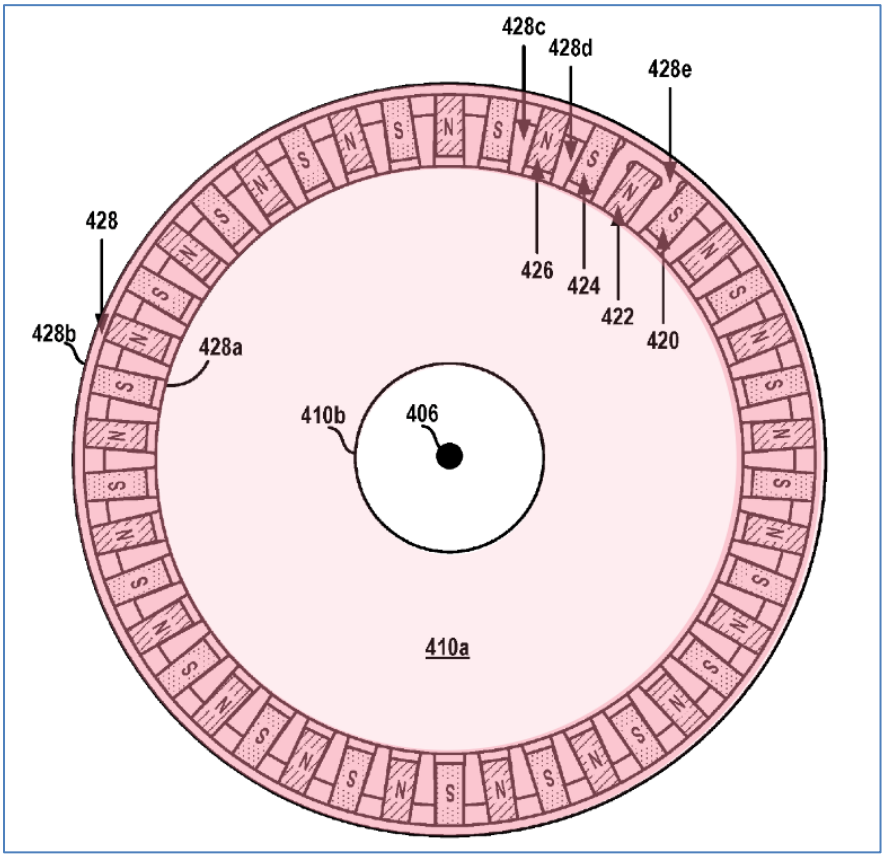
(i) Limitation 14(i): a rotor assembly coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles

181. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[i].

182. I understand that in the ITC action the parties have proposed constructions of the term "rotor assembly coupled to the rotor circuit board." I also understand that no construction has been adopted. I understand that the ITC Staff proposed that the term should be given its "plain and ordinary" meaning. EX1020. I understand that Ouster proposed that the term allows the rotor assembly to be "directly or indirectly connected" to the rotor circuit board. EX1021. I further understand that Hesai proposed that the term should be construed to require that the rotor assembly be "attached or mounted directly to the rotor circuit board." EX1022. Because Johnson discloses that the "rotor assembly" is directly mounted to the rotor circuit board, it is my opinion that this limitation is met under all of these

constructions.

183. For instance, Figure 3B shows a rotor assembly with magnets mounted concentrically on the rotor circuit board around the axis of rotation (306), and the magnetic poles form an alternating pattern (*i.e.*, each magnetic pole has a polarity ("N" or "S") opposite the polarity of adjacent poles):



EX1005, Fig. 3B, 8:26-30, 11:1-15. Johnson teaches the magnets are "mounted to" the rotor circuit board (*id.*, 11:15-21, 11:64-65, 7:6-21), such that they are "coupled to" the rotor circuit board under any party's proposed construction.

(j) Limitation 14[j]: a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a

transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment

184. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[j].

185. As I have previously explained, Pacala teaches a light ranging device (LiDAR device) that is mounted on a rotating turret 60 within the enclosure. EX1004, [0013], Figs. 1-2.

186. Pacala's LiDAR device includes a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic. For instance, Pacala explains that spinning turret 60 includes "optical transmitters" and "collimation" lens 80, as shown in Figure 2, that "irradiat[e] the target or landscape with light, with pulses [] from a laser." *Id*., [0004], [0013], Fig. 2. A POSITA would have understood the collimation lens is a bulk transmitting optic and that the optical transmitters which emit light are an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic. Indeed, the '515

Patent teaches embodiments in which the transmit module comprises an emitter and collimating lens that generate and transmit light pulses. EX1001, 8:26-42.

187. Pacala's light ranging device further includes a receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses. For instance, Pacala explains that the spinning turret 60 also includes "receivers" and "focusing" lens 80, as shown in Figure 2, that receive "reflect[ed] light." EX1004, [0004], [0013], Fig. 2. Pacala also explains that the reflected pulses are "detect[ed] and analyze[ed]" to determine "which pulses represent reflections from solid objects whose sensing is desired (*e.g.*, vehicle, person, wall, tree) as opposed to errant pulses reflected by environmental elements whose sensing is not desired (*e.g.*, rain, dust)." *Id.*; *see also id.*, [0014] (teaching that the time-to-digital converter circuitry can be "integrated into the pixels of a detector array (*e.g.*, Single-Photon Avalanche Diode [SPAD] array)" of the LiDAR). A POSITA would have understood the focusing lens is a bulk receiver optic and that the optical receivers are detector circuitry operable to detect reflected portions of light. Indeed, the '515 Patent teaches embodiments in which the receive module comprises a lens that is "configured to receive light and focus the received light to a focal plane." EX1001, 8:1-10.

188. The transmit module and receive modules are illustrated below in orange and blue:

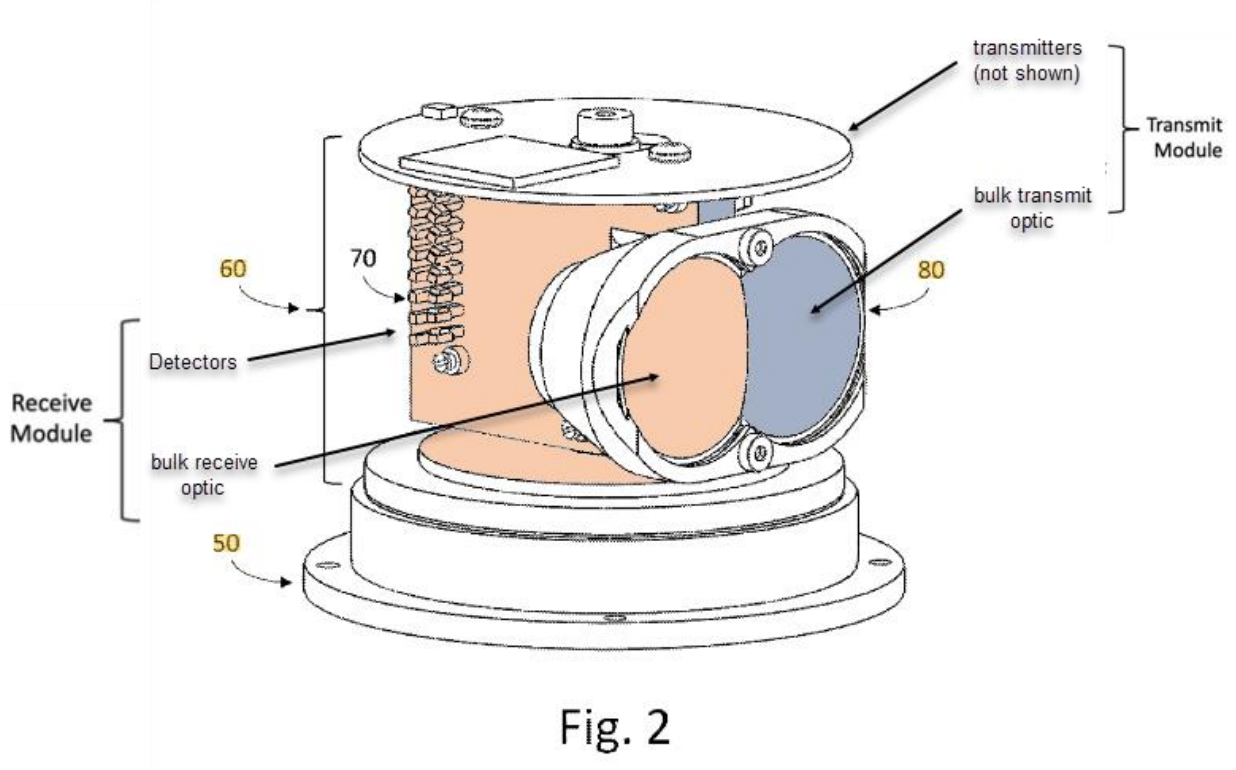
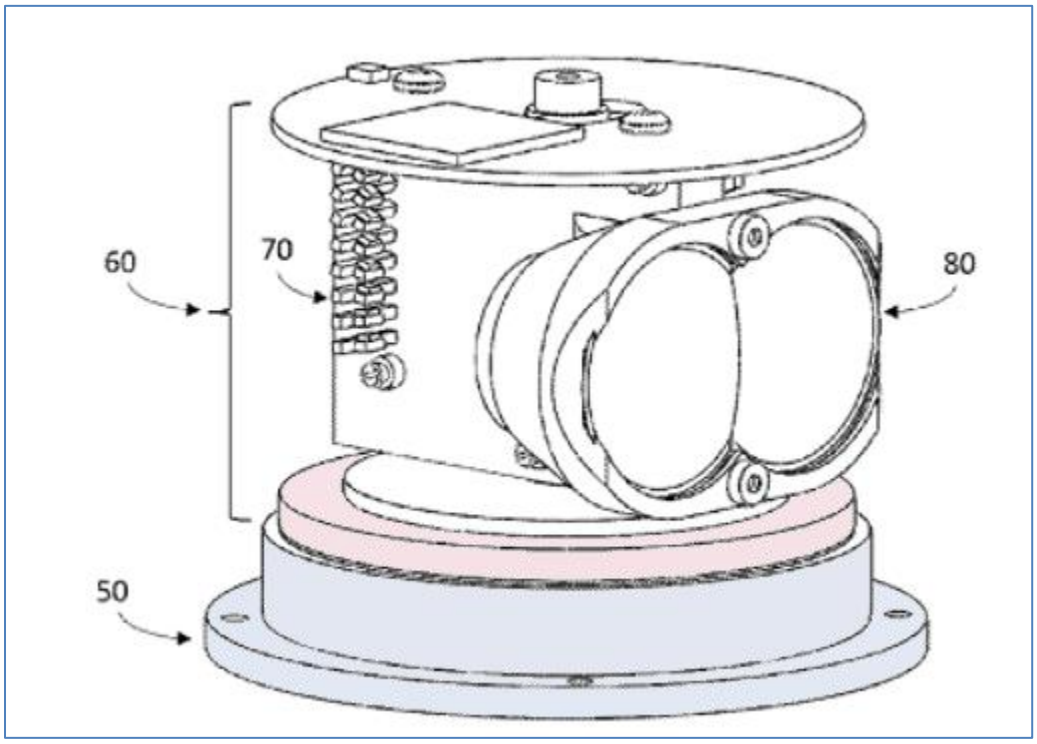


Fig. 2

Id., Fig. 2.

189. Further, Pacala states that window 40 of the enclosure is transparent at the wavelength of the laser used in each transmitter. *Id*., [0012]. A POSITA would have understood that the window is transparent at such a wavelength so that the emitted light pulses (electromagnetic radiation pulses) that are transmitted through the bulk transmitting optic can exit window 40, and so that reflected light from the objects in the surrounding environment can be received through the window 40.

190. Further, Pacala discloses that its device is intended to rotate on a turret 60 (red) about fixed base 50 (blue):



EX1004, [0012]-[0013], Fig. 2. When the teachings of Johnson and Pardhan are applied to Pacala, the LiDAR device of Pacala would be mounted on the top surface of Pardhan's support component, such that it rotates with the rotor circuit board mounted on the bottom surface of the support component. Indeed, I explained in connection with Limitation 14[e] that the support component and rotating platform of Johnson and Pardhan are implemented within the turret (red) of Pacala, such that the LiDAR device of Pacala would rotate with the support component and rotor circuit board that is coupled to it. Further, Pardhan also teaches that the LiDAR device should be mounted to the upper surface of the support component (the upper surface of plate 720), as does Zhang. *See* EX1006, 10:61-64, 16:49-64, Fig. 4, Fig. 7A-7B; EX1007, pg. 6, Fig. 1 (showing mounting holes (13) on the support

component for mounting the LiDAR device).

(k) Limitation 14[k]: a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft

191. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies Limitation 14[k].

192. Johnson's stator circuit board includes a stator assembly with a plurality of stator elements, as I discussed in connection with Limitation 14[h].

193. Johnson discloses a stator driver circuit configured to provide a drive signal to the stator elements in the stator assembly. For instance, Johnson discloses circuity 150/250 (and controller 234) on the stator platform that provides a drive signal, *i.e.*, causes an "electrical current to flow through" the plurality of "coil windings." EX1005, 18:6-24, 9:35-47, 6:35-48, Fig. 1-2. The drive signal "causes a torque or force" that rotates the rotor circuit board about axis 406. *Id*., 13:51-58.

194. Further, Johnson teaches that circuity 150/250 (and/or controller 234) is formed on the stator circuit board (EX1005, Fig. 2, 9:32-34), which I showed above in connection with Limitation 14[e] is implemented within the enclosure of Pacala. Thus, in the combined system the stator driver circuit would be disposed within the enclosure of Pacala and would induce a force that causes rotation of the

rotor circuit board and light ranging device about the shaft 734 of Pardhan.

2. Independent Claim 1

(a) Limitation 1(a): A light ranging system comprising

195. Limitation 1[a] is the same as limitation 14[a]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(b) Limitation 1(b): an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure

196. Limitation 1[b] is the same as limitation 14[b]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(c) Limitation 1(c): a shaft disposed within the enclosure and defining an axis of rotation

197. Limitation 1[c] is the same as limitation 14[c]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(d) Limitation 1(d): a stator circuit board disposed within the enclosure along a first plane perpendicular to the axis of rotation and fixedly coupled to the base of the enclosure

198. Limitation 1[d] is the same as limitation 14[d]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(e) Limitation 1(e): a support component rotationally coupled to the shaft and comprising a sleeve fitted over the shaft and a plurality of arms extending away from the sleeve

199. Limitation 1(e) recites "a support component… comprising a sleeve

fitted over the shaft and a plurality of arms extending away from the sleeve." This portion of the limitation is the same as Limitation 14[e]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

200. Limitation 1[e] further recites that the support component is "rotationally coupled to the shaft." As I explained in connection with Limitations 14[e]-[f], Pardhan's support component includes "bearings coupled between the shaft and the support component allowing the support component to rotate around the axis of rotation" that is defined by the shaft. Thus, the support component is also "rotationally coupled to the shaft."

(f) Limitation 1(f): a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover

201. Limitation 1(f) recites a "a rotor circuit board coupled to the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover." Limitation 14[g] also recites "a rotor circuit board coupled to… the support component and disposed within the enclosure along a second plane parallel to the first plane and between the first plane and the top cover." Thus, it is my opinion that this limitation is satisfied for the same reasons.

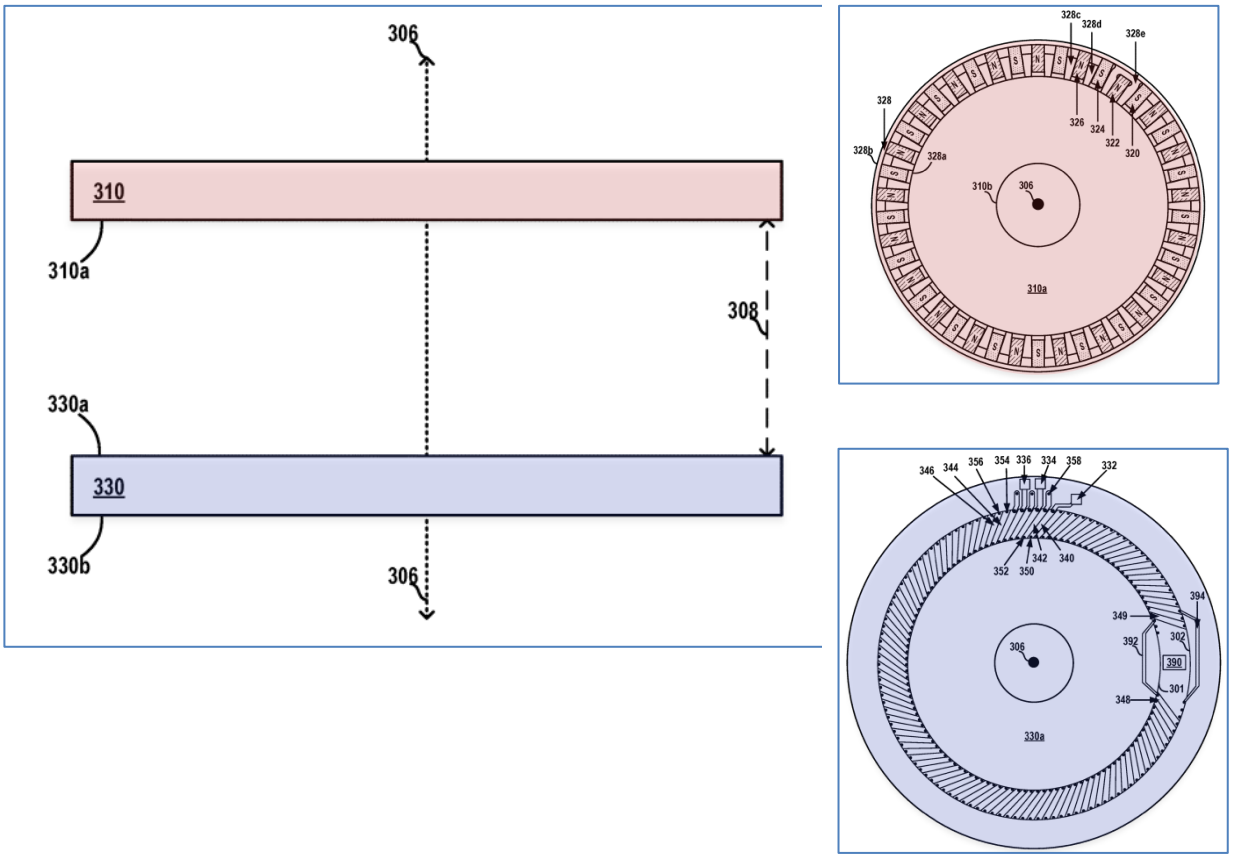
(g) Limitation 1(g): a stator assembly disposed between the first and second planes and coupled to the stator

circuit board, the stator assembly comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil wound around a magnetic core

202. I showed in connection with Limitation 14(h) that Johnson includes a "a stator assembly coupled to the stator circuit board and comprising a plurality of stator elements arranged annularly about the axis of rotation, each of the plurality of stator elements including a coil."

203. Limitation 1(g) further recites that the stator assembly is "disposed between the first and second planes." In my opinion, Johnson satisfies this additional requirement.

204. For instance, Johnson explains that the stator assembly may be a multi-layer circuit board with an upper layer (Figure 3C) disposed along a top side (310a) of the stator platform, and a lower layer (Figure 3D) disposed "between sides 330a and 330b [bottom side]" of the stator platform. EX1005, 12:1-6. These layers are shown below:



Id., 10:58-63, 11:66-12:6, 12:44-67, Figs. 3A, 3C. Johnson also teaches that an additional layer may also be disposed along the bottom side (330b) of the stator platform. *Id.*, 12:1-6. The stator assembly would thus be positioned between a first plane defined by the lower most layer of the multi-layer circuit board and the second plane defined by the rotor circuit board on the stator platform 330. *Id.*

205. Limitation 1(g) also recites the further limitation that the stator coils are wound around a magnetic core. Johnson discloses this limitation. For instance, Johnson teaches that "a magnetically permeable core" "can be inserted between the two layers of FIGS. 3C and 3D" to "enhance[] the stator-platform magnetic field."

EX1005, 14:1-10 . For instance, a "ring shaped" core may be disposed in the middle layer of platform 330 "between the conductive structures of Figs. 3C and 3D," such that each coil would be wound about the core. *Id*; *see also id.*, 5:41-56.

206. Indeed, a POSITA would have understood that to promote efficient motor operation, the middle layer between Figures 3C and 3D should be an annular ring extending from at least element 301 to element 302 (as those elements are depicted in Figure 3C of Johnson). This arrangement of a magnetic core helps focus the magnetic field created by currents in the conductors so that they interact more closely with the magnetic field created by the rotor magnets, as Johnson teaches. *See id*., 14:1-10 ("middle layer may act as a magnetic core that enhances the stator-platform magnetic field").

(h) Limitation 1(h): a rotor assembly disposed between the first and second planes and coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles

207. I showed in connection with Limitation 14(i) that Johnson includes "a rotor assembly coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles."

208. Limitation 1(h) further recites that the rotor assembly is "disposed between the first and second planes." In my opinion, Johnson satisfies this additional requirement.

209. Johnson states that the rotor circuit board shown in Figure 3B corresponds to an "outer layer of a circuit board" disposed on the underside (310a) of the rotor platform. "outer layer of a circuit board" disposed on the bottom side (310a) of the rotor platform. EX1005, 10:55-60, Fig. 3A-B. The rotor assembly (*e.g.*, the magnets) are mounted to the rotor circuit board facing the stator circuit board shown in Figure 3C. Because the rotor assembly is mounted on the surface of the rotor circuit board facing downwards to the stator platform, it is positioned between a first plane (defined by the lower most layer of the stator platform) and a second plane (defined by the top side of the rotor circuit board).

(i) Limitation 1(i): a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment

210. Limitation 1[i] is the same as limitation 14[j]. Thus, it is my opinion

that this limitation is satisfied for the same reasons.

(j) Limitation 1(j): a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft

211. Limitation 1[j] is the same as limitation 14[k]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

3. Claim 2: The light ranging system of claim 1 wherein the shaft is hollow and the system further comprises a communication channel that extends through the hollow shaft allowing ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure in a fixed relationship to the stator circuit board

212. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 2.

213. Johnson discloses a communication channel that allows ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure. For instance, Johnson explains that its rotor (210/310) and stator (230/330) platforms can include communication interfaces (216/236) to provide "wireless or wired communication" for "data and instructions" to pass "between platforms":

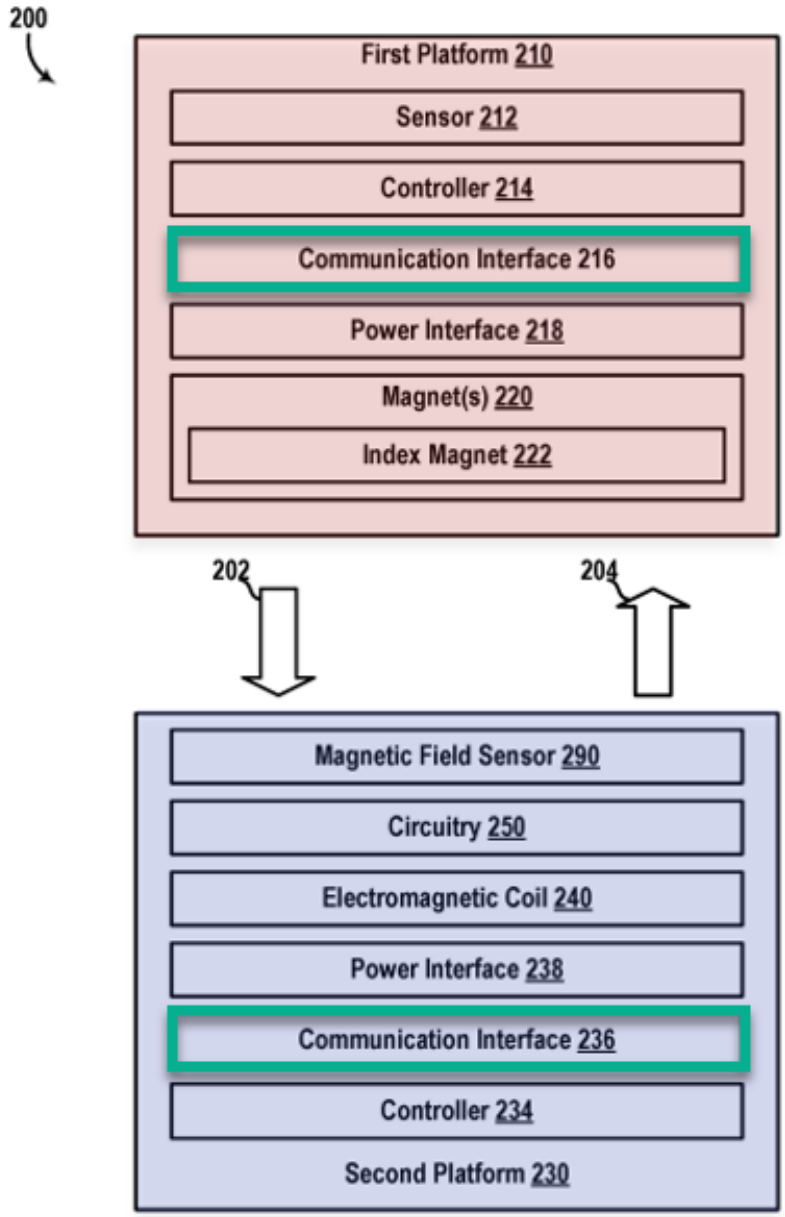


FIG. 2

EX1005, Fig. 2, 7:47-63, 9:1-18. The communication interface 216 transmits signal 202—which may represent data collected by LiDAR sensor 212—to process circuitry on the stator platform, and may receive signals 204 for operating the sensor from communication interface 236. *Id.*, 9:1-15.

214. Although Johnson does not expressly state that the communication

channel extends through a hollow shaft, a POSITA would have found this to be obvious in view of Pardhan.

215. Implementing a communication channel through a hollow shaft was a well-known way to communicate signals electrically in a device such as LiDAR. For instance, Pardhan teaches: "Rotor 702 may connect to stator 700 by way of a rotational joint system that includes rods/shafts 708 and 714." EX1006, 19:63-65. As shown in Figure 7A, the rod/shaft is hollow so that "wires including power and data connections may pass through rods 708 and 714 to connect the LiDAR device to a power source and a computing device (*e.g.*, a computing device configured to autonomously operate a vehicle based on data from the LIDAR device)":

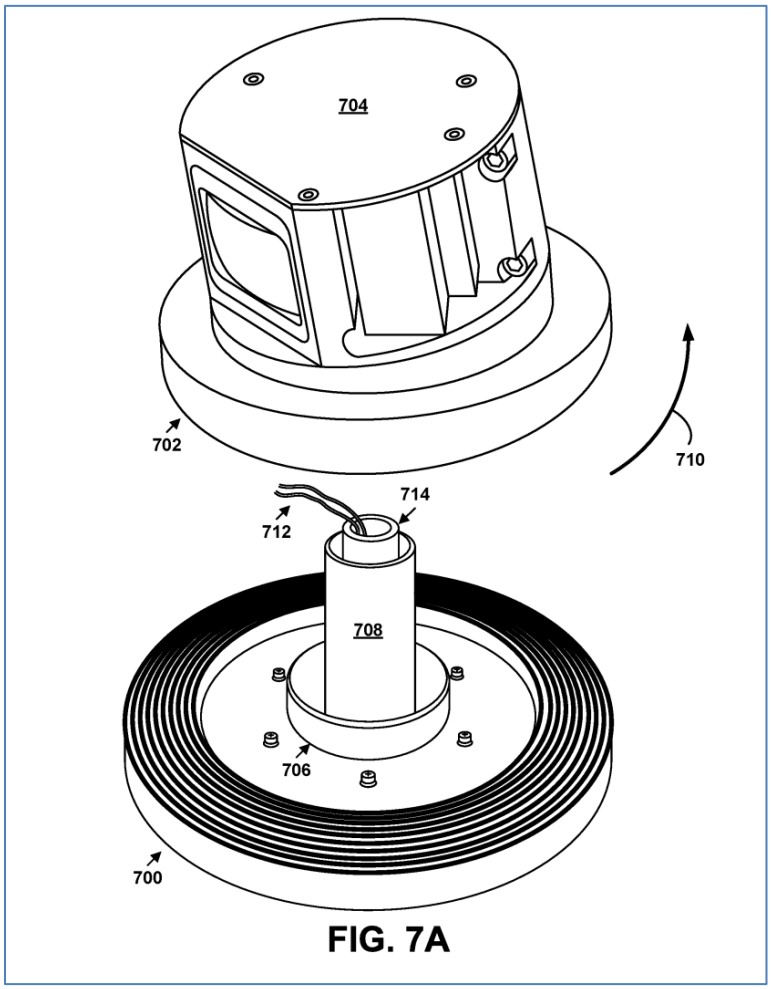


FIG. 7A

Id., 20:30-35, Fig. 7A. Figure 7B of Pardhan uses the same configuration of a hollow shaft 734, such that a POSITA would have understood that it too can include a communication channel through its hollow shaft. *Id*, Fig. 7B.

216. Applying Pardhan's teachings to Johnson, the combined system would continue to exchange the sensor data and instructions (202/204), as taught in Johnson, but would do so through a communication channel that extends through the hollow shaft (as taught in Pardhan).

217. Zhang also reinforces the obviousness of using a hollow shafting

system to provide a communication channel for sensing data. For instance, Zhang teaches a "hollow shaft" in the "middle" of a rotating structure that is designed to "accommodate a signal transmission structure." EX1007, Abstract. Zhang explains that implementing the communication channel within the hollow shaft is desirable because, for instance, it prevents interference in the transmission. *Id*., pg. 1 (having space in the hollow shaft "to accommodate a signal transmission structure… prevents mutual interference of signal transmissions systems."), 6 ("In summary, the present utility model adopts the design of a hollow shaft system with a large diameter at the bottom. The stator and rotor portion of the rotary system are made into a shaft system, and there is sufficient space in the middle to place the signal transmission structure and electrical power transmission structure."). Thus, a POSITA would have also found it obvious to implement Johnson's communication channel through a hollow shaft in view of Zhang.

4. Claim 4: The light ranging system of claim 1 further comprising: a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane

218. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 4.

219. Johnson includes a third circuit board that is fixedly coupled to the base of the enclosure. For example, Johnson explains that electronics and circuitry of the stator platform may be mounted to different layers of a multilayer-PCB. EX1005, 11:66-12:17, Fig. 2, 3A-3D. In one example, Figures 3C and 3D may correspond to a layer on "side 330a [top side] of platform 330" and "a layer between sides 330a and 330b [bottom side]" (respectively). *Id*. Johnson also teaches that a layer may be formed on the bottom surface 330b in some embodiments. *See, e.g., id.*, 15:14-44 ("sensor 390 can be alternatively positioned along a different side (*e.g.*, side 330b) of platform 330"). When combined with Pacala, the board layers of the stator platform would be fixedly coupled to the base of the enclosure such that the lower most circuit board would be a "third circuit board" positioned in a plane parallel to and between the base and the stator circuit board.

220. Johnson also includes a "fourth circuit board" coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane. For example, Johnson states that Figure 3B is an "outer layer of a circuit board" that corresponds to the bottom side (310a) of the rotor platform. *Id*., 10:57-62. Johnson's disclosure of an "outer layer" at least suggest that "inner" layers may be included in order to mount other electronic components. Indeed, Johnson teaches that the rotor platform may implement additional components (*e.g.*, other sensors, processors, controllers and circuitry) that

are not shown in Figure 2B. *Id*., 12:61-65. And Johnson refers to components of the rotor platform being mounted on a layer of the "printed circuit board (PCB) or *other circuit board*." EX1005, 11:61-65. A POSITA would have understood that it would be necessary to mount electronic components to a fourth circuit board where space on the circuit board of Figure 3B is insufficient. In fact, Pardhan reinforces this understanding by expressly stating that "various types of electronic components and/or systems" may be "disposed within the LIDAR device 100 in any feasible manner." EX1006, 6:35-41; *see also id*., 6:6-16 (LiDAR device 100 includes the rotating and stationary platforms). Moreover, Johnson states that the LiDAR sensor may be mounted on the rotor platform (Ex. 1004, Fig. 2), such that a POSITA would understand that the surface of the rotor platform may include a control board for the ranging device. *See also* Ground 6, Limitation 22(e.iii) (discussing Yan). The additional circuit board would be a "fourth circuit board" and because the LiDAR sensor of Pacala is mounted above the rotor platform, the fourth circuit board would be between the rotor circuit board of Figure 3B (which is on the underside of the rotor platform) and the enclosure top (which is the top most portion of the light ranging system).

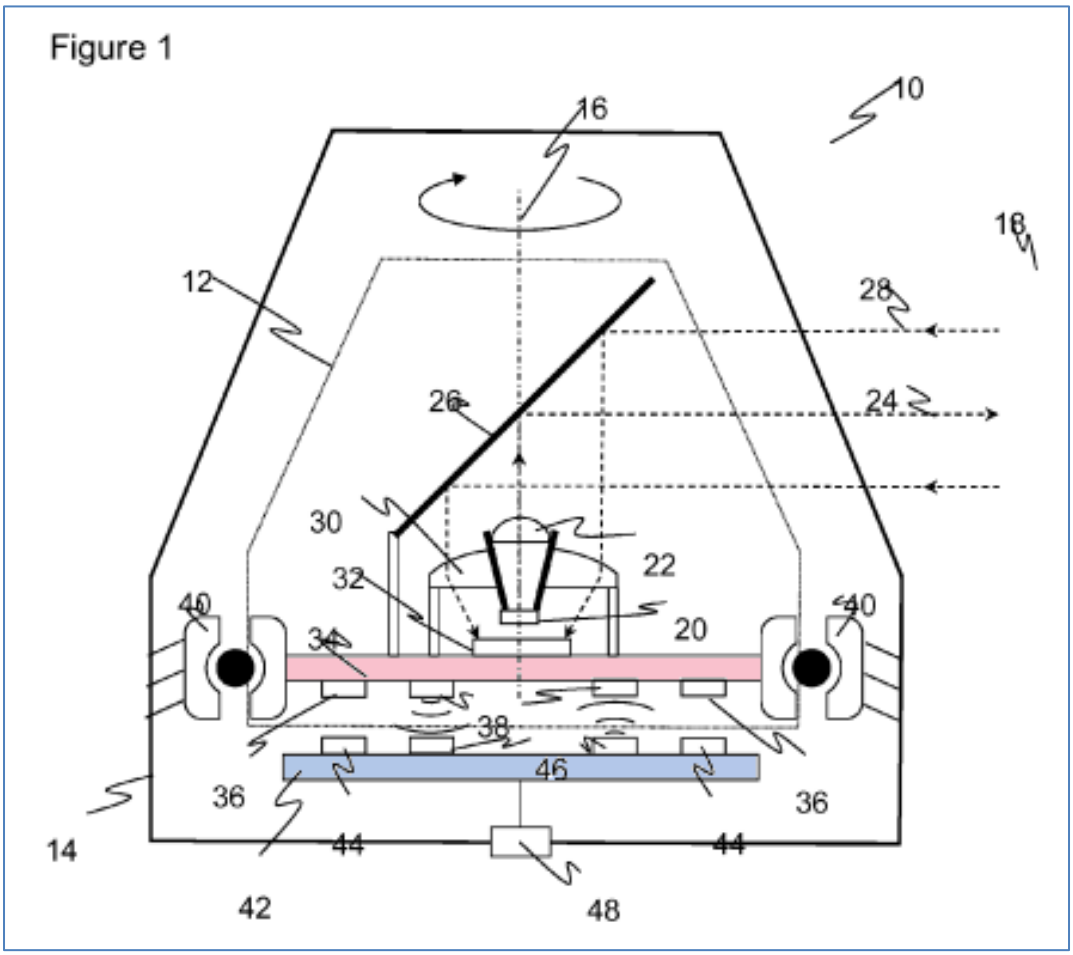
221. If Ouster contends that separate layers of a multi-layer circuit board are a single circuit board, claim 4 would still be obvious in my opinion.

222. A POSITA would have understood that the layers of a multi-layer

circuit board may be implemented as discrete circuit boards. A multi-layer circuit board and multiple discrete circuit boards are interchangeable in terms of operation. Thus, the decision to use a multi-layer circuit board or multiple discrete circuit boards is a straightforward design choice that presents no novel or unexpected results. Indeed, Johnson expressly states that a "multi-layer PCB" is merely "one implementation," and that "other implementations are possible." EX1005, 12:4-18. Johnson also states that "those skilled in the art will appreciate that other arrangements" of its components can be used, and that its circuit boards and components can be provided in "any suitable combination and location." *Id*., 19:66-20:4. And implementing discrete circuit boards is less expensive and easier to manufacture than a multi-layer circuit board. EX1040 ("The advantages of single-layer PCBs over other types of boards are numerous"). It can also be manufactured in less time. *Id*. Modifying Johnson to use separate circuit boards would have amounted to simple substitution of one known element (a multi-layer PCB) for another (separate PCBs) to obtain predictable results (electronics mounted on separate circuit boards).

223. Additionally, a POSITA would also recognize that LiDAR electronics may not fit within the space provided by a single stator and rotor circuit board, such that additional circuit boards are needed. This understanding of a POSITA is confirmed by prior art references that reflect the knowledge of a POSITA, such as

U.S. Patent No. 9,606,230 ("Nubling"). For instance, Nubling teaches a prior art LiDAR device that, in one embodiment, includes a "first circuit board (34)" (rotor circuit board in red) and a "second circuit board 42" (stator circuit board in blue):



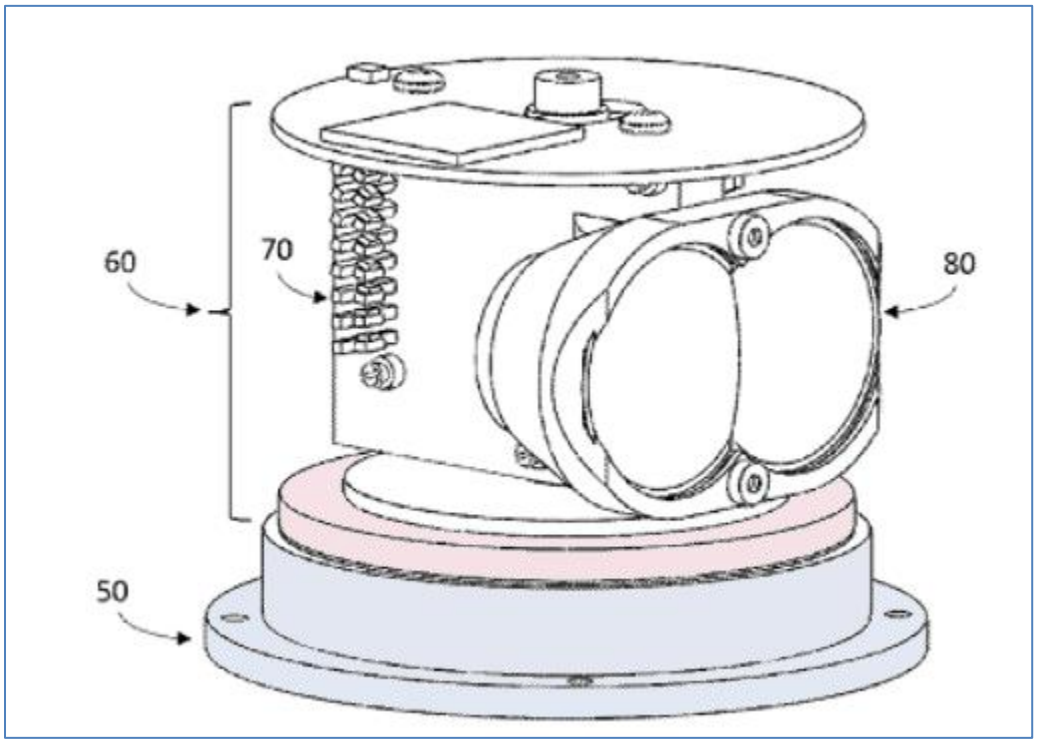
EX1043, Fig. 1. Nubling goes on to explain that "further circuit boards" may be needed to provide additional "space and capacity" for mounting system electronics. EX1043, 6:1-8 ("more circuit board can be provided" for "sufficient space and capacity."), 2:62-3:3 ("It is additionally conceivable to provide at least one further circuit board…"), Fig. 3. For example, Nubling states that additional circuit boards

may be "electrically connected" to the first and second circuit boards and serve as an "extension" that provides space for mounting system electronics. *Id*. "[A]most any desired functions can be distributed over the first circuit board, the second circuit board and further circuit boards in the sampling unit and/or base unit." *Id*., 3:36-40. Thus, particular in view of Johnson's teaching that the rotor and stator platforms may include additional components that are not shown, a POSITA would have found it at least obvious to implemented the claimed "third circuit board" and "fourth circuit" board to provide additional space for mounting system electronics.

5. Claim 5: The light ranging system of claim 4 wherein the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth circuit board and the enclosure top with the transmit module mounted to a first portion of the ranging device housing and the receive module mounted to a second portion of the ranging device housing directly adjacent to the first portion

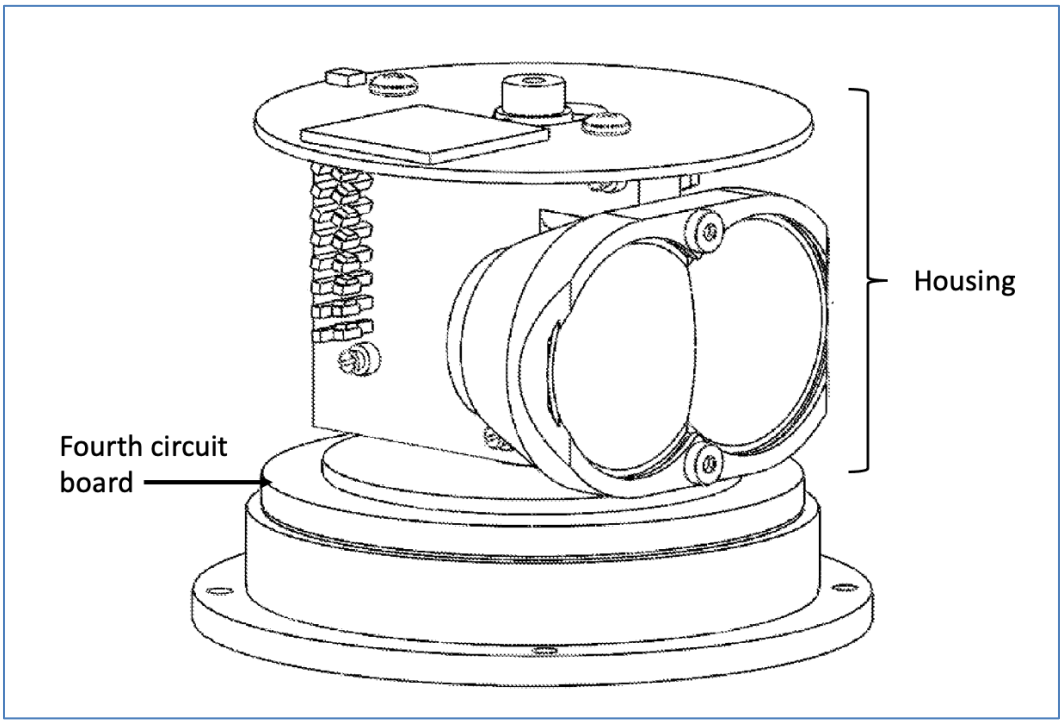
224. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 5.

225. As I explained in connection with Limitation 14[c], the rotor-stator structure of Johnson and Pardhan would be implemented within Pacala's spinning turret (red) and static base (blue):



EX1004, Fig. 2.

226. As I discussed in connection with Claim 4, Johnson teaches or suggests a fourth circuit board that would also be disposed within the spinning turret (red) of Pacala. Thus, in the combined system the LiDAR housing is disposed between the top of the enclosure and the fourth circuit board, as illustrated below.



Id., Fig. 2.

227. Further, as I showed in connection with Limitation 14[j], Pacala teaches that the transmit module of the light ranging device is mounted to a first portion of the device, and the receive module mounted to a second portion of the device directly adjacent to the first portion:

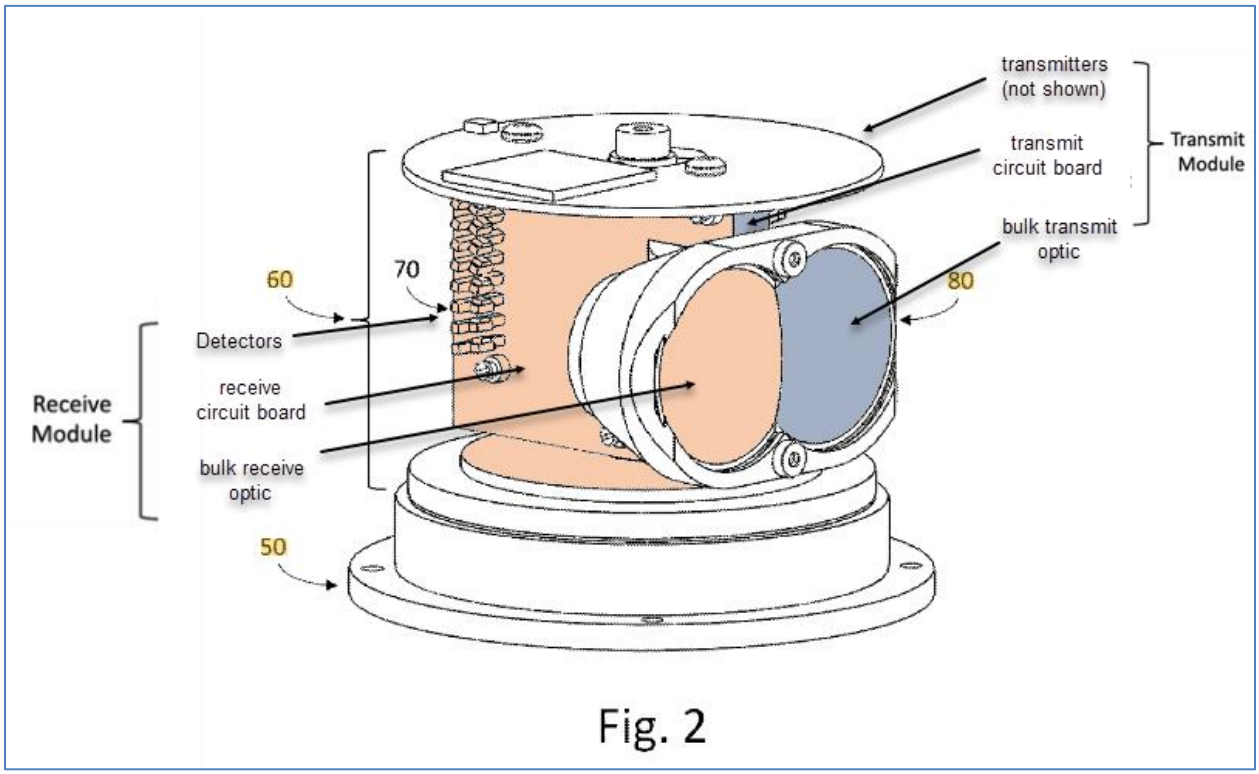


Fig. 2

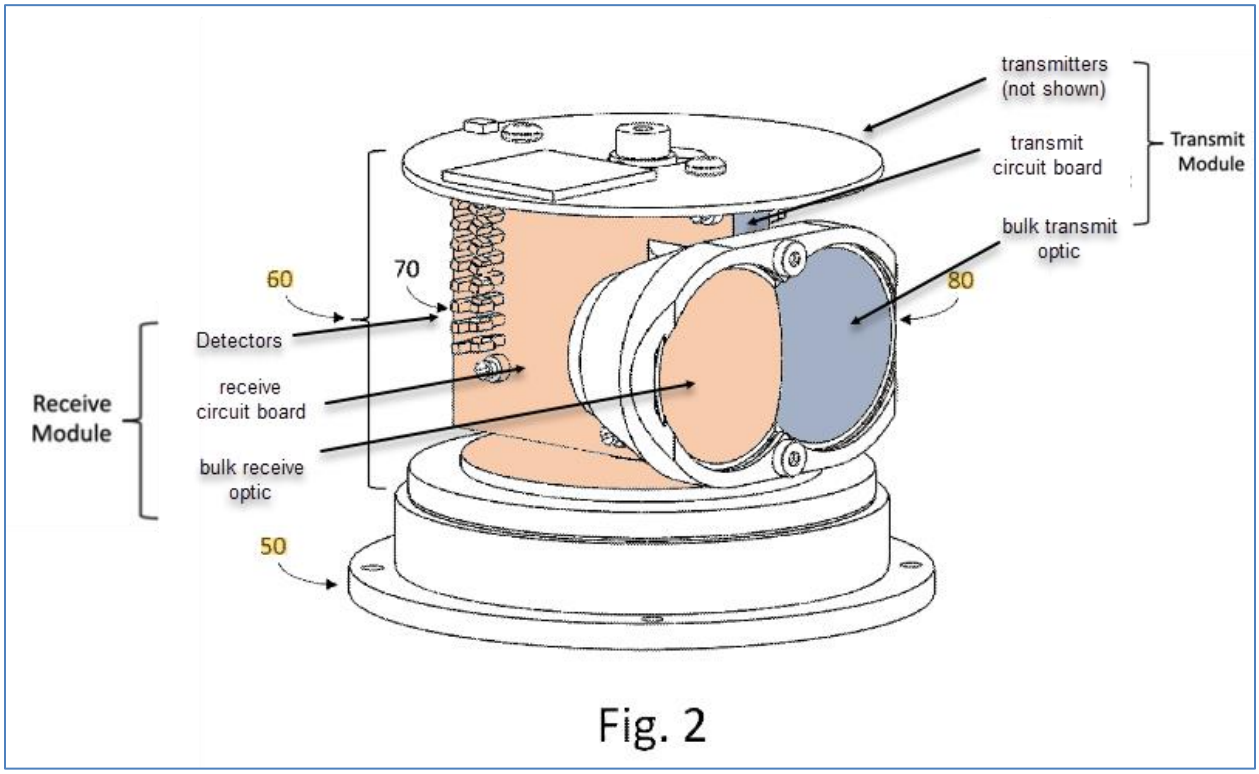
EX1004, Fig. 2, [0012]-[0014].

6. Claim 6: The light ranging system of claim 5 wherein transmit module comprises a fifth circuit board with supporting circuitry for the illumination source and the receive module comprises a sixth circuit board with supporting circuitry for the detector circuitry, and wherein the fifth circuit board is mounted to the first housing portion of the ranging device housing and aligned parallel to the axis of rotation and the sixth circuit board is mounted to the second housing portion of the ranging device housing and aligned parallel to the axis of rotation

228. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 6.

229. As I explained in connection with Limitation 14(j), the LiDAR device of Pacala includes a transmit module comprising a plurality of transmitters

(illumination sources) and associated circuitry and a receive module comprising a plurality of detectors and associated circuitry. A POSITA would at once recognize that the circuitry of the transmit module and receive module can be implemented on separate circuit boards, each behind the respective bulk transmit optic and receive optic and parallel to the axis of rotation, as shown below:



Id., Fig. 2, [0012]-[0014]. The separate circuit boards would be the claimed fifth circuit board and sixth circuit board in the combined system.

230. Indeed, a circuit board is typically designed to fit into a device based on space requirements and can be designed to be both parallel as well as perpendicular to the axis of rotation. A POSITA would at once recognize both of these finite options and understand that either orientation could be implemented with

predictable and known results. For instance, a POSITA would have understood that transmitters and associated electronics (*e.g.*, firing circuits) are positioned behind the transmit optic, and that the most straightforward manner in which to mount the transmitters and electronics would be on a vertically mounted circuit board. The same would have been true with respect to the photodetectors and associated circuitry, which would have been most obvious to mount on a separate vertically mounted circuit board.

231. Positioning the circuit boards in this configuration was a straightforward design choice that was known in the art. For instance, Pennecot teaches a transmit block 220 with transmitters mounted on one circuit board, and receive block 230 with detectors mounted on another circuit board, with both boards mounted parallel to the axis of rotation of the device, as shown in Figure 2C below:

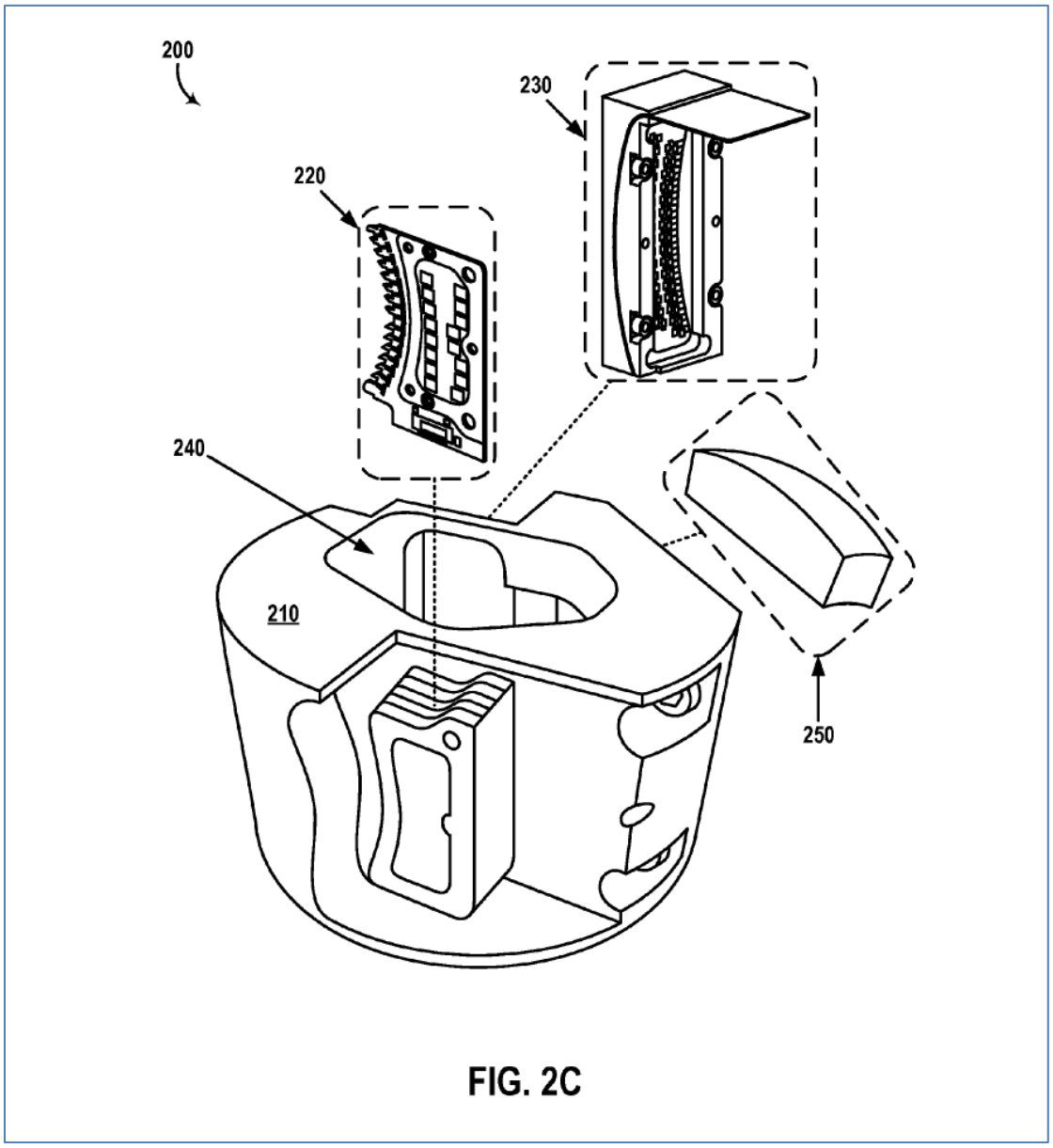


FIG. 2C

EX1014, 4:25-5:25, 8:14-28, Fig. 2C; *see also* Ground 3.

7. (Claims 7) The light ranging system of claim 1 wherein the annular arrangement comprises a plurality of separate permanent magnets / (Claim 16) The light ranging system of claim 14 wherein the plurality of magnetic poles rotor in the annular arrangement of the rotor assembly comprise a plurality of separate permanent magnets

232. The additional limitations of claims 7 and 16 are materially the same.

In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies these additional limitations.

233. For example, Johnson illustrates an annular arrangement of separate magnets, as shown in Figure 3B below:

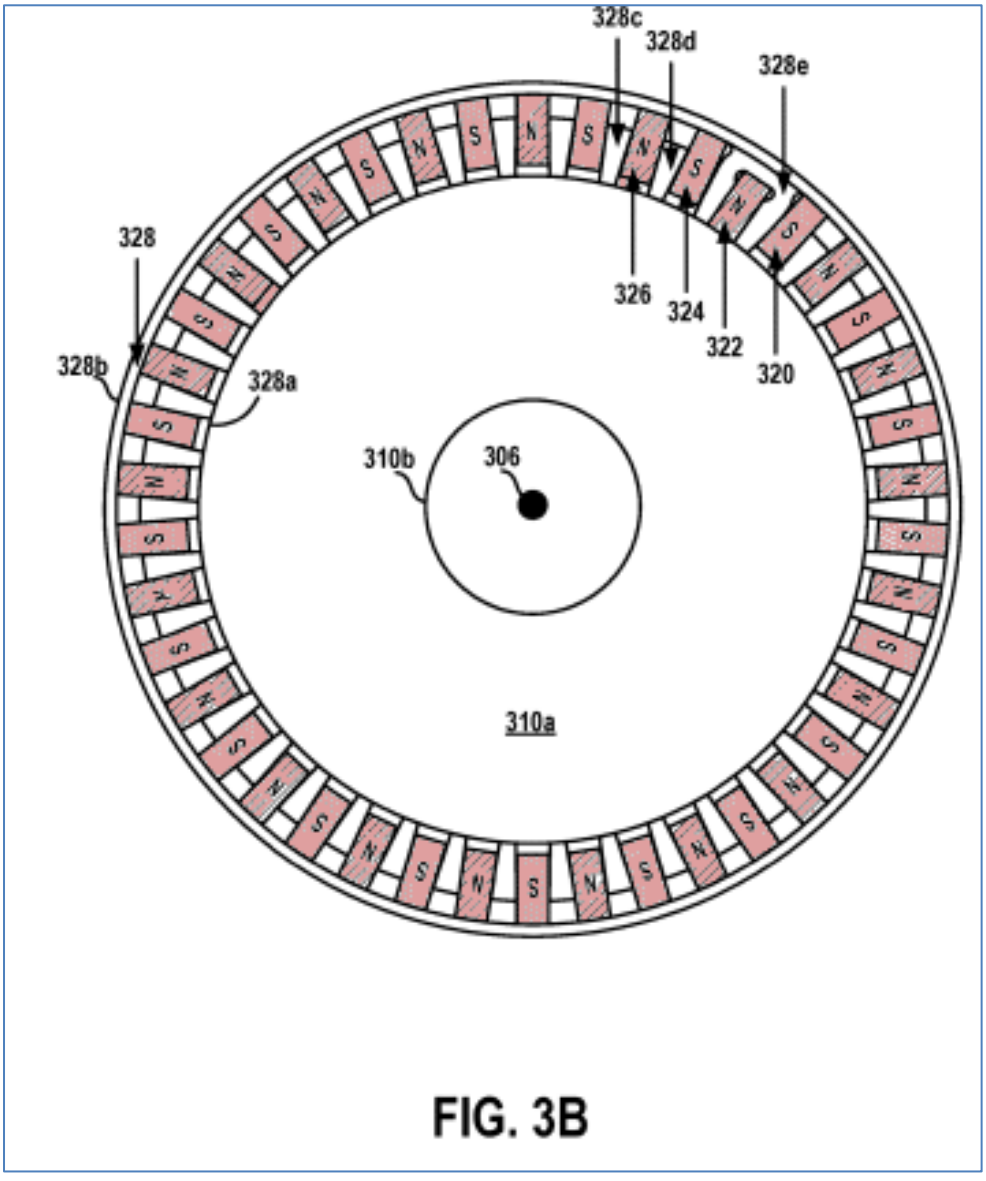


FIG. 3B

EX1005, Fig. 3B. Johnson states that the magnets may be implemented using ferromagnetic material (*id.*, 8:16-19), which a POSITA would have understood to

include permanent magnets. *See also* EX1045, 3:23:27 ("In one example, the plurality of magnets can be implemented as permanent magnets (e.g., ferrimagnets, etc.) that are arranged along a periphery of a circularly shaped disk on a side of the disk (e.g., the first side) that is facing the second side of the second platform.").

8. (Claim 8) The light ranging system of claim 1 further comprising circuitry to compute ranging data based on the reflected portion of the electromagnetic radiation pulses / (Claim 19) The light ranging system of claim 14 wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the illumination source and the detection of reflected portions of the electromagnetic radiation pulses by the receive circuitry

234. Claim 8 recites that the light ranging system includes "circuitry to compute ranging data based on the reflected portion of the electromagnetic radiation pulses." The '515 Patent indicates that "[t]he term ranging data may refer to any data that can be transmitted from a laser ranging device." EX1001, 10:20-34. Thus, ranging data includes data for determining "distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the illumination source and the detection of reflected portions of the electromagnetic radiation pulses by the receive circuitry," as recited by claim 19.

235. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitations of claims 8 and 19.

236. A POSITA would have understood that these limitations recite a basic function of a light ranging device, as I showed in Section VI.A. Pacala itself confirms that this is a basic functionality of a LiDAR device: "A lidar sensor…can measure the distance to a target or objects in a landscape, by irradiating the target or landscape with light, using pulses (or alternatively a modulated signal) from a laser, and measuring the time it takes photons to travel to said target or landscape and return after reflection to a receiver in the lidar module." EX1004, [0004]. Such measurements may be "conventional[ly]" performed by circuitry. EX1004, [0005].

237. This understanding is also confirmed by a prior art Waymo patent which states: "A LIDAR device can… determin[e] the distance to the object according to the time delay between the transmitted pulse and the reception of the reflected pulse." EX1015, 1:14-22.

9. Claim 9: The light ranging system of claim 1 wherein the stator driver circuit is configured to rotate the rotor assembly at a rate between 10 to 30 Hz

238. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 9.

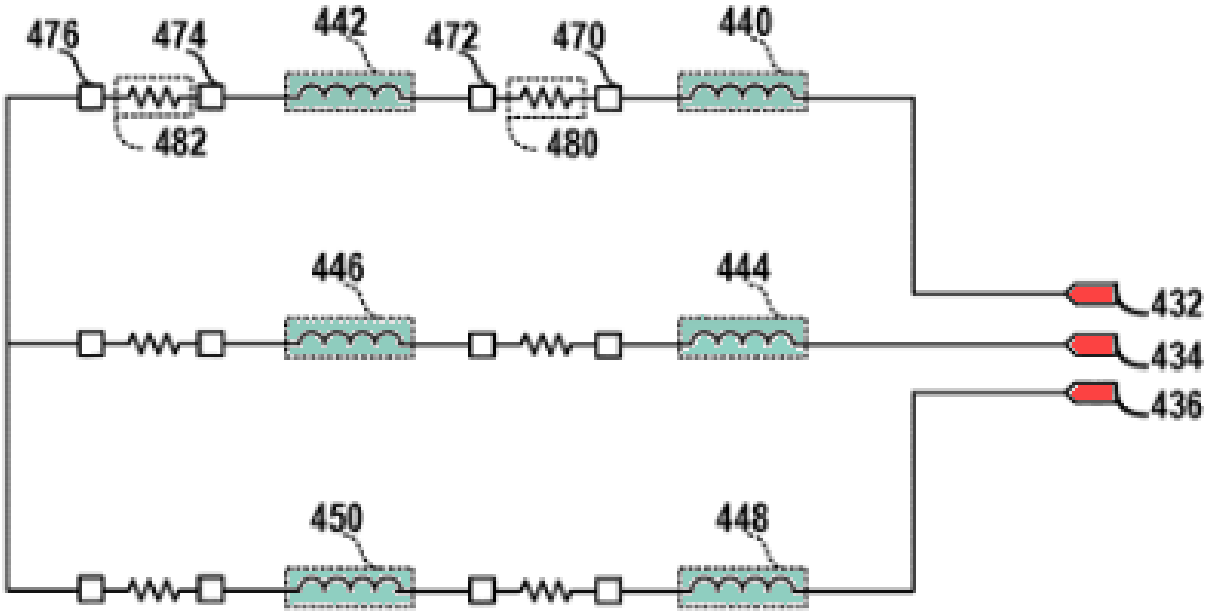
239. For instance, Johnson discloses a stator driver circuit (circuitry 150/250) that can be configured to achieve a desired rotation speed for the rotor assembly. EX1005, 18:33-36, Figs. 5-6. And Pardhan confirms that the "rotating platform" can "rotate at various rates," including "15 Hz." EX1006, 10:32-41 ("the

LIDAR device 100 may be configured to have a refresh rate of 15 Hz (*e.g.*, fifteen complete rotations of the LIDAR device 100 per second)… scanning a 360° FOV [field-of-view] around the vehicle fifteen times every second.").

10. Claim 11: The light ranging system of claim 1 wherein a number of stator elements in the plurality of stator elements is a multiple of three and the stator driver circuit is configured to provide a 3-phase alternating signal to the plurality of stator elements.

240. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 9.

241. Johnson discloses that the stator elements in the plurality of stator elements is a multiple of three. For example, Figure 4 of Johnson shows "leads (*i.e.*, contacts 432, 434, 436)" that correspond to "contacts 332, 334, 336" in Figure 3C:



EX1005, 15:64-16:8, 17:1-9, Fig. 4. "[C]oil windings 440, 442, 444, 446, 448, 450"

(green) are configured in "a parallel circuit configuration relative to the power leads," thereby forming three stator elements that each comprise two coils.

242. Johnson also discloses a stator driver circuit (150/250) that provides "a modulated power signal, such as 3-phase alternating current (AC) signal for instance, that flows through coil windings." *Id.*, 6:29-48, 9:32-48, 12:37-44, 15:64-16:8, Figs. 1-2.

11. Claim 17: The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement

243. In my opinion, the Pacala-Johnson-Pardhan-Zhang combination satisfies the additional limitation of claim 17.

244. Figure 2 of Johnson illustrates a wireless power transformer (power interface 218/238) that is integrated directly onto the stator (210/310) and rotor (230/330) platforms and that is configured "for wireless (or wired) transmission of power between" the platforms:

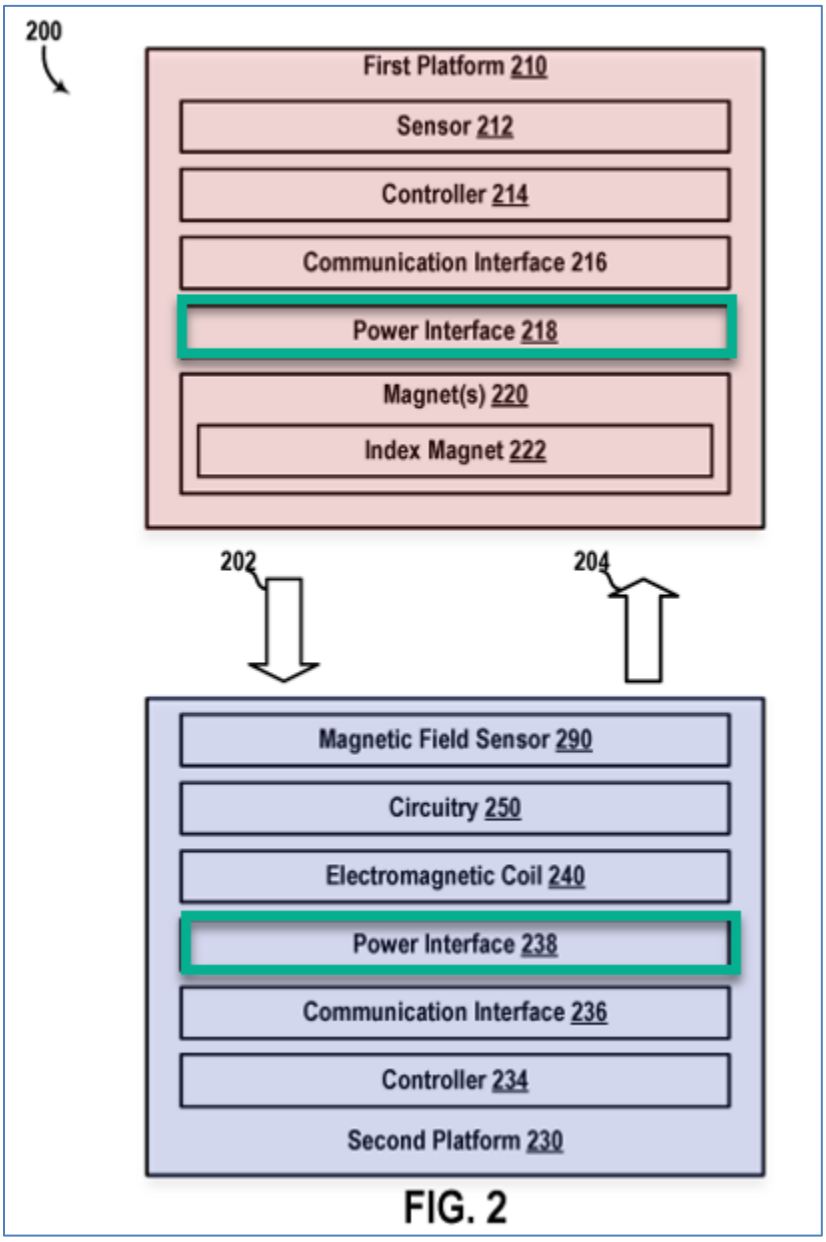
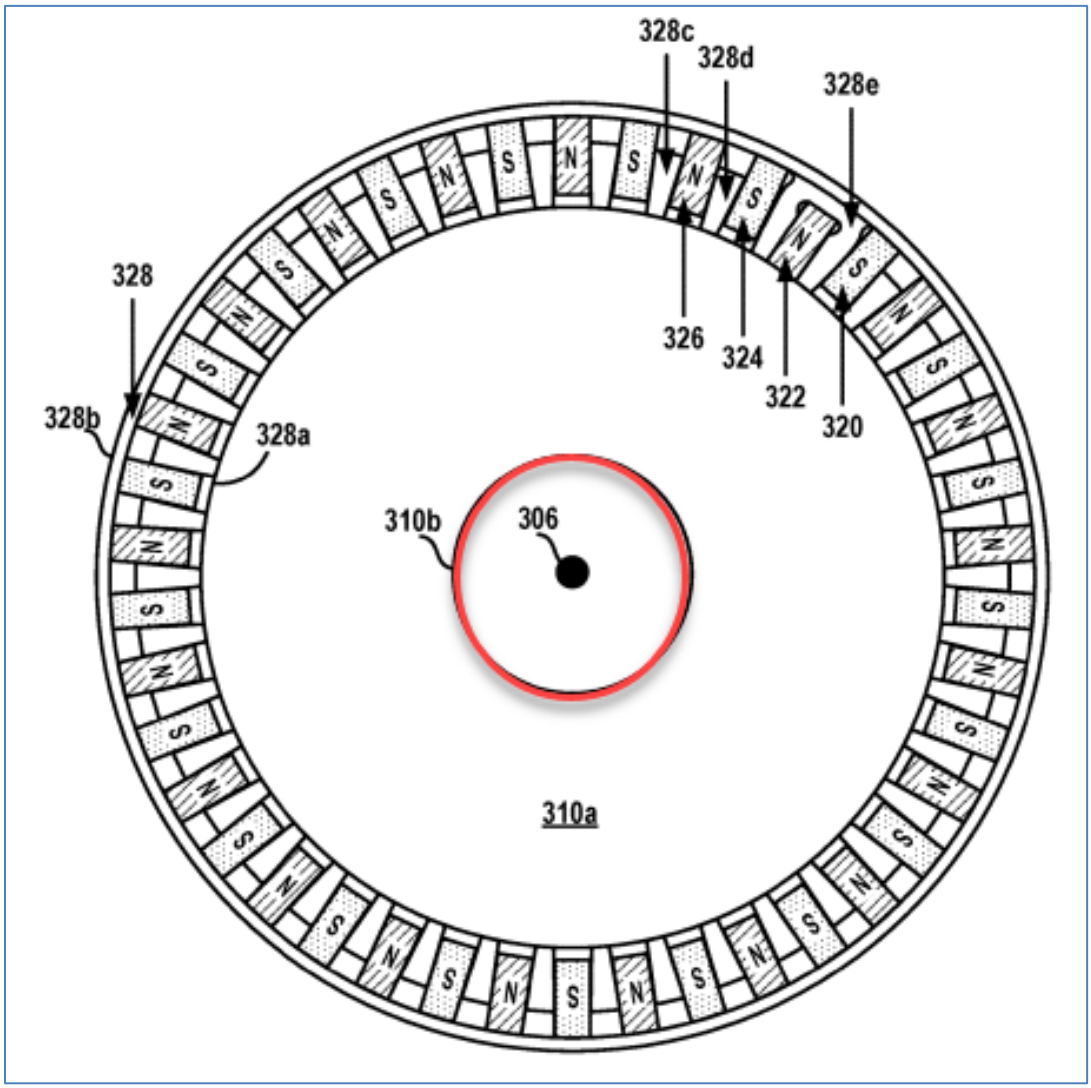


FIG. 2

EX1005, Fig. 2, 7:64-8:15, 9:19-31, 11:51-60.

245. The wireless power transformer includes first and second annular transformer coils that are mounted on the stator and rotor circuit boards. For instance, Johnson teaches that a first annular transformer coil can be mounted on the rotor circuit board around the region 310b:



Id., Fig. 3B, 11:51-60. Stator "platform 330" includes "a similar transformer coil" on the stator circuit board of Figure 3C. *Id*.; *see also id*., 8:4-9, 9:22-31.

246. The transformer coils are also in an opposing relationship with one another. For instance, Johnson teaches the circuit board of Figure 3B may be disposed on the bottom side (310a) of rotor platform 310 and the circuit board of Figure 3C may be disposed on the top side (330a) of stator platform 330, such that the two annular transform coils face one another in an opposing relationship. *Id*.,

8:4-8 ("transformer coils can be arranged around a center region of platform 210 opposite to corresponding transformer coils included in platform 230."), 11:62-67, 11:66-12:16, Fig. 3A-C; *see also id*., 7:15-18.

247. Although the embodiments of Figures 3B-3C show the transformer coils positioned closer to the center region of the stator and rotor circuit boards than the stator elements and rotor assembly, Johnson teaches that "[o]ther configurations are possible." *Id*., 8:14-15. For instance, a POSITA would have understood that motor coils can also positioned outside of the stator elements and rotor assembly, as recited in Claim 17. Indeed, the location of the transformer coils in this respect is a straightforward design choice that relates to considerations such as the amount of torque and power needed for the device and the space available in the center region of the circuit board. For instance, for an axial-flux motor, like that disclosed in Johnson, the amount of torque provided by the motor generally depends on how close or far away the magnets are from the central rotating axis. A larger motor with a larger radius will create more torque, while one with a smaller radius will generate less torque. A POSITA would have understood that in certain LiDAR systems the size of the motor and torque output that is needed will result in a smaller motor radius such that the space in the center region would be insufficient to fit the transformer coils along with the other electronics of the system. Further, certain LiDAR applications may need to use larger transformer coils that have a larger radius to

increase the power and transfer distance, such that the transformer coils would not fit within the perimeter of the motor and stator coils. In short, the location of the motor magnets and coils is a design choice with no novel or unpredictable results.

12. Motivation to Combine

248. In my opinion, a POSITA would have been motivated to combine the teachings of Pacala, Johnson, Pardhan and Zhang in the manner I discussed above for a number of reasons.

249. ***First***, Pacala states that its LiDAR device rotates on a "spinning turret 60" relative to a "static base 50" (EX1004, [0013]), but does not disclose the details (*e.g.*, the arrangement of magnets, stator coils, power transformers, and communication interfaces) of the rotation structures. Thus, a POSITA would have looked to references describing the implementation of such structures, including Johnson, Pardhan and Zhang.

250. ***Second***, implementing the rotor-stator structure taught by Johnson and Pardhan within the enclosure of Pacala constitutes the use of a well-known technique to improve similar devices in the same way. By the priority date of the '515 patent, rotor-stator structures were well-known and widely used within the enclosure of a LiDAR device. EX1005, Fig. 3A; EX1006, Fig. 7B, EX1009, 4:53-64. A POSITA would have been particularly motivated to implement the rotor-stator structure of Johnson-Pardhan that integrates the motor and distributed electronics within the

rotor-stator structures because it improves Pacala by providing "a more compact design and/or efficient use of space." *See* EX1045, 4:1-6. In addition, Johnson does not expressly disclose the details regarding the shaft and support structure that couples the stator and rotor platforms, but this is ripe for predictable improvement by integrating the known structural elements described in Pardhan. Johnson and Pardhan are naturally suited for one another given the complimentary nature of their rotor-stator structure and that they are both Waymo patents.

251. ***Third,*** implementing the rotor-stator structure taught by Johnson and Pardhan within the enclosure of Pacala would also have involved simple substitution of one known element (the rotation structure of Pacala) for another (the rotation structure of Johnson-Pardhan) to obtain predictable results (a LiDAR device configured to rotate on the rotational structure). The rotational structure taught by Johnson and Pardhan are expressly designed to rotate a LiDAR device like Pacala and serve the same function as Pacala's static base and spinning turret.

252. ***Fourth***, the prior art includes express motivations to apply Pardhan and Zhang's teachings regarding a support structure with arms to Johnson. For instance, Johnson discloses that a LiDAR device may be mounted on its rotor-stator structure, which, as explained in Pardhan, may "generate excess heat" that made it difficult to operate the device "within a safe operating temperature range" without techniques for "transfer[ing] excess heat away from" the rotating LiDAR device. EX1006,

4:54-5:80, 19:2-6. Pardhan and Zhang teach known techniques for transferring heat away from a LiDAR device that are complimentary and can be implemented via a support structure on the rotor. For instance, the rotor support structure of Pardhan permits heat to be transferred away from the LiDAR device to a cooling plate at the base. EX1006, Abstract. Similarly, Zhang's support structure includes heat dissipation passages between a plurality of arms to further "dissipate heat generated during the operation of the internal rotating structure, thereby increasing the operating life of the rotating structure." EX1007, pg. 6, Fig. 1. Thus, a POSITA would be motivated to use the support structure disclosed in Pardhan alone and in combination with Zhang to support the LiDAR device in a manner that provides for efficient heat dissipation, ventilation, and increased operating life.

253. ***Fifth***, a POSITA would have also been motivated to modify Pardhan's support structure to use a bearing housing with arms based on the knowledge of a POSITA. Pardhan employs one type of bearing housing but by the time of the '515 Patent bearing assemblies were well-known and it was understood that different designs could be used in a rotor-stator structure interchangeably. Moreover, a POSITA would have understood that when mounting LiDAR to a rotor platform it is desirable to minimize vibrations, and that a bearing housing with arms furthers this goal by providing additional support. Indeed, vibrations in a rotating system can arise from various factors. If the attachment between the rotor and stator is not

firm, it can lead to excessive movement, oscillation, and vibration. These vibrations can result in decreased performance, increased wear and tear, and potential damage to the system. When the rotor and stator are securely and tightly connected, it enhances the structural integrity of the system, reducing the possibility of relative movement or looseness between the two components. This helps minimize vibrations caused by any imbalance, misalignment, or other dynamic forces during operation. In fact, it was understood that vibrations and movements were a substantial cause of motor failures, such that it was important for the bearing assemblies and shaft to be "held in their positions firmly." EX1031, 329-331 ("Section 6.2.5 Prevention of Bearing Axial Movement"). Thus, employing a bearing housing with arms involves simple substitution of one known bearing housing (that in Figure 7B of Pardhan) for another (one of the known designs that includes arms) and would result in an improved structure that benefits from additional support provided by the arms.

254. ***Sixth***, a POSITA would have been motivated to modify Johnson so that the transformer coils are positioned on the outside of the stator and rotor elements, rather than on the inside. Initially, Johnson expressly discloses its configuration is exemplary and others are possible. EX1005, 7:64-8:15. There are only a finite number of configurations (*e.g.*, inside or outside the motor magnets and windings) each of which were known and yielded predictable results. Further, a POSITA

would have understood that the position of the transformer coils is a straightforward design choice. For instance, the permitter of the motor magnets and windings depends on the size of the motor, such that certain applications may use smaller motors with limited space in the center region for system components (*e.g.*, transformer coils, communication interfaces, etc.). It may also be desirable in certain applications to use larger transformer coils that do not fit in the limited center region space.

255. Indeed, a POSITA would have understood that larger coils allow for a larger separation distance between the primary and secondary coils while maintaining a reasonable power transfer efficiency. This means that the rotor and stator can be placed at greater distances from the power source and still receive sufficient power. Additionally, larger coils offer a wider charging area, allowing for greater flexibility in device placement and alignment. Further, larger transformer coils can handle higher power levels due to their larger cross-sectional area, and thus larger transformer coils may be beneficial where the electronics and circuitry on the device require additional power. As a result, transformer coils are often arranged outside the center region of the boards (and thus outside the motor coil perimeter) where there is more space.

256. ***Seventh***, a POSITA would have been motivated to combine Pacala, Johnson, Pardhan and Zhang because the combination merely combines prior art

elements according to known methods to yield predictable results. Pacala describes a LiDAR unit that teaches the claimed light ranging device and components (*e.g.*, housings, transmitter modules, receiver modules, *etc*.). Johnson describes a rotor-stator platform and the details of the rotor-stator elements and electronics (*e.g.*, the motor coils, magnets, transformer coils, driver circuit, communication interfaces, *etc*.). And Pardhan and Zhang describes known support structures and shafts that may be used to rotationally couple rotor and stator boards together. The prior art I have discussed in this declaration confirms that these elements are known and conventional components that can be combined together using straightforward engineering and assembly techniques. The combination would yield predictable results with each element continuing to perform the same function as it does separately.

13. Reasonable Expectation of Success

257. A POSITA also would have had a reasonable expectation of success in combining these references to achieve the claimed invention.

258. ***First***, light ranging devices and rotor and stator platforms with integrated PCB motors to which a light ranging device is mounted have been widely studied before the priority date of the ‘515 Patent. Indeed, the Background of the ‘515 Patent acknowledges that LiDAR systems (including spinning LiDAR systems) were well-known and the claims of the ‘515 Patent recite only conventional

components of such light ranging device. EX1001, 1:30-41, 1:42-48. Thus, the state of the art confirms that a POSITA would have had a reasonable expectation of success.

259. ***Second***, a POSITA would have understood that assembly techniques for rotating light ranging system were well-known and predictable. Brushless DC motors, including disc-shaped motors like those in Johnson and Pardhan are widely used across many applications and employ conventional components, as I explained in Section VI.D. In fact, Johnson and Pardhan disclose that the rotor-stator components may be printed on circuit boards and that the supporting structures for coupling these boards to one another or to housings use bearings, shafts, and other conventional structures. Moreover, the prior art I discuss in this declaration confirms that basic electrical engineering designs and principles can be used to integrate a light ranging device with a stator-rotor platform that includes motor and other distributed electronics.

B. Ground 2: Pacala, Johnson, Pardhan, and Zhang in further view of Cai renders obvious Claims 2, 4-6 and 17.

260. I showed in connection with Ground 1 that Pacala, Johnson, Pardhan, and Zhang render obvious claims 2, 4-6 and 17. To the extent Ouster argues otherwise, these claims are also obvious in further view of Cai, as I discuss below.

261. Below, I begin by showing how the combined system renders obvious

claims 2, 4-6 and 17. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.B.6-7.

1. Claim 2: The light ranging system of claim 1 wherein the shaft is hollow and the system further comprises a communication channel that extends through the hollow shaft allowing ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure in a fixed relationship to the stator circuit board

262. Cai illustrates a laser ranging device in which a brushless DC motor 13 (red) is located between a rotating disk 11 and fixed base 12:

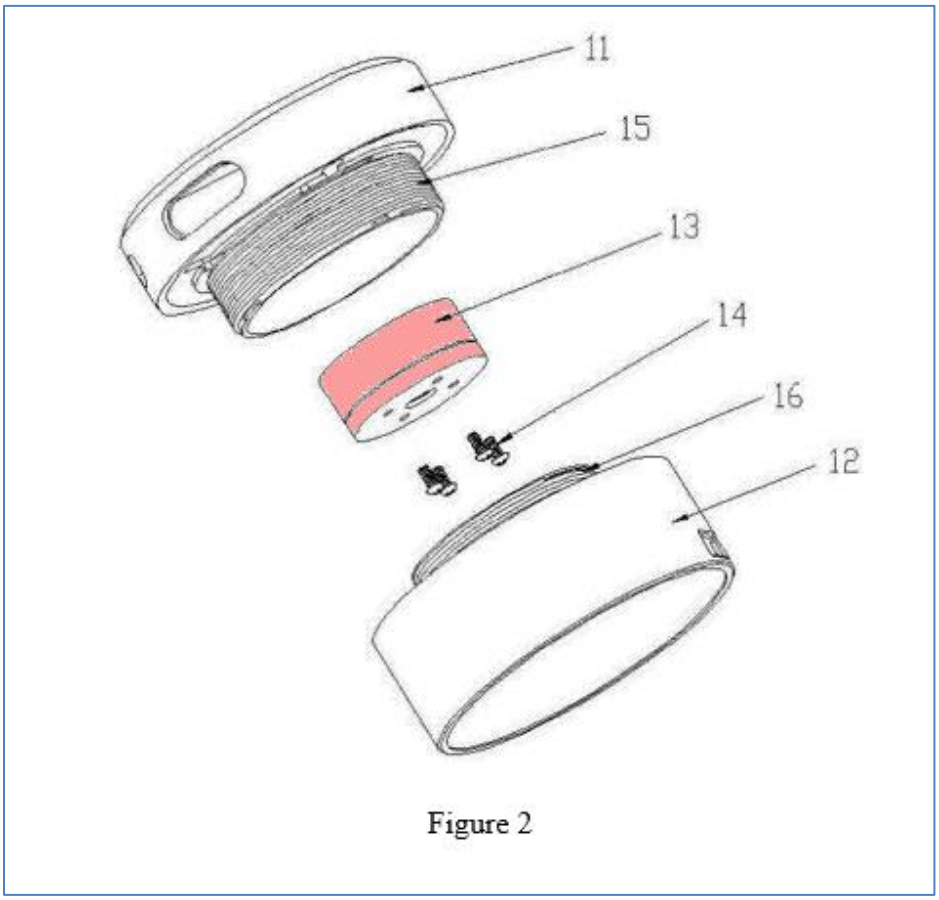


Figure 2

EX1008, [0025], Fig. 2. As can be seen in Figure 4, the motor (13) includes a hole (131) through the center region:

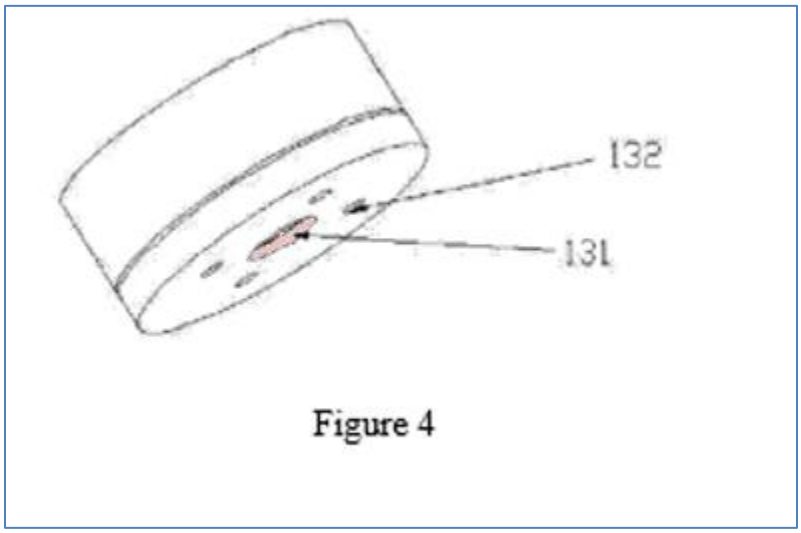
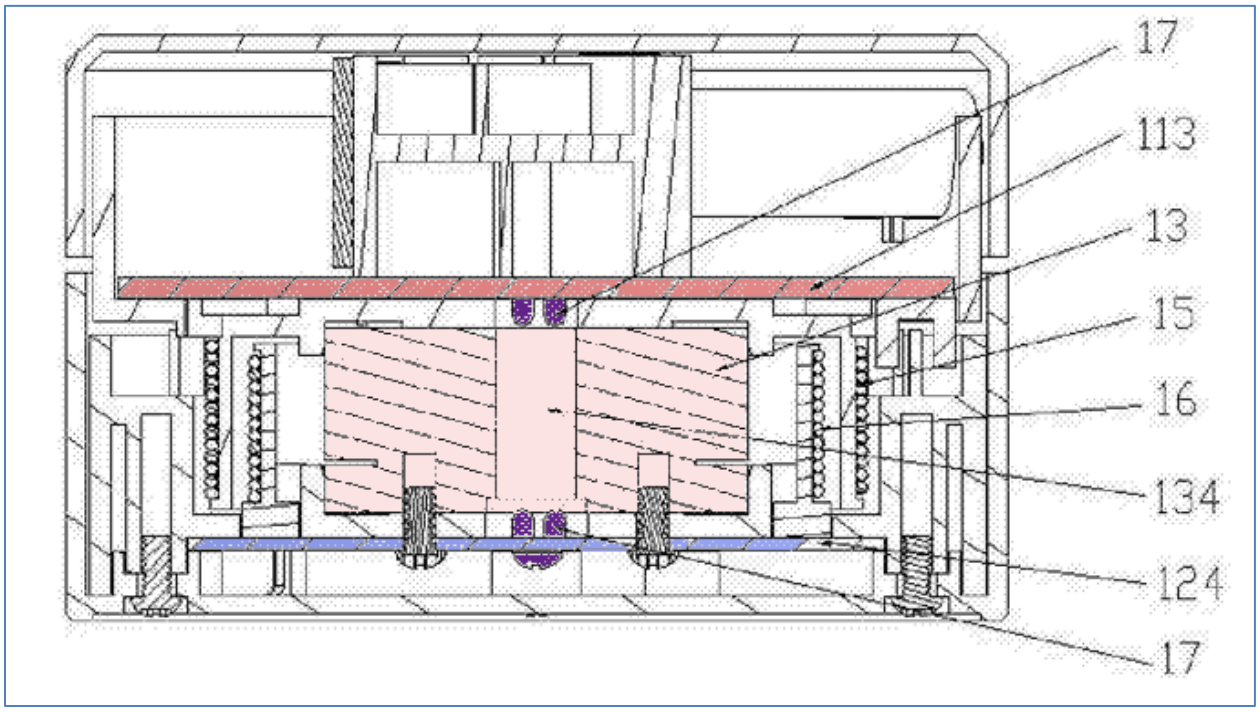


Figure 4

Id., Fig. 4, pg. 4, Claim 6.

263. Cai teaches a communication channel that is formed through the hole (131) in the center of the motor (hollow shaft) for the exchange of data (*e.g.*, sensor data). Specifically, signal transceiver devices (17) are mounted in the center of a "first circuit board (113)" and a "second circuit board (124)" above and below the hole (131) to allow for the exchange of sensor data and instructions, as illustrated in Figure 8:



Id., [0030], Fig. 8; *see also id*., Fig. 4.

264. When the teachings of Cai are applied to Johnson and Pardhan, circuit boards (113 and 124) would be positioned on the upper surface of Pardhan's support component and lower surface of the stator circuit board with signal transceivers (17) mounted in the center region of those circuit boards. Indeed, Johnson explains that its rotor and stator circuit boards form a "PCB motor" (EX1005, 13:57-60) and in view of Pardhan those rotor and stator circuit boards are attached via a support component comprising a sleeve fitted over a hollow shaft. Thus, coupling circuit board 113 on the support component and circuit board 124 below the stator circuit board would result in the circuit boards having the same relative position as disclosed in Cai (namely, they would be positioned above and below a hollow shaft

in the motor). And a POSITA would also understand that positioning the circuits boards 113 and 124 above and below the motor is desirable because it would allow the signal transceivers to be mounted in the center region, facing one another to form a communication channel through the hollow shaft (as disclosed in Cai). Thus, the combined structure would include a communication channel that extends through the hollow shaft of Pardhan in the same way that Cai discloses a communication channel through the hollow hole in the center of motor 13.

2. Claim 4: The light ranging system of claim 1 further comprising: a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane

265. In my opinion, the additional limitation of claim 4 is also obvious in further view of Cai.

266. Johnson includes a stator circuit board and a rotor circuit board, as I discussed in connection with Ground 1, Claims 1 and 14. The stator and rotor circuit boards are a first and second circuit board. Further, the stator and rotor circuit boards form a "PCB motor" with motor magnets on the rotor and motor coils on the stator. EX1005, 13:57-60, Figs. 3B-3D. Thus, a POSITA would have understood that Johnson's rotor and stator circuit boards and the PCB motor that they form

correspond to the brushless DC motor 13 of Cai that I illustrated above in connection with claim 2.

267. As I also explained in connection with claim 2, Cai explains that further circuit boards 113 and 124 may be positioned above and below the stator and rotor circuit boards with signal transceivers mounted thereon in order to form a communication channel through a center region of the motor. Figure 3 shows the rotating disk portion (11) of the light ranging device that is above the motor (13) and Figure 5 shows the base portion (12) that is below the motor, along with the transceiver circuit boards 113 and 124:

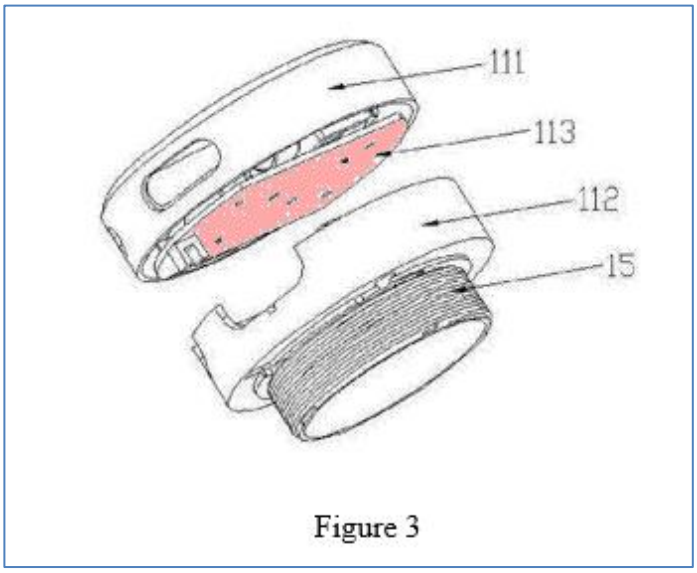


Figure 3

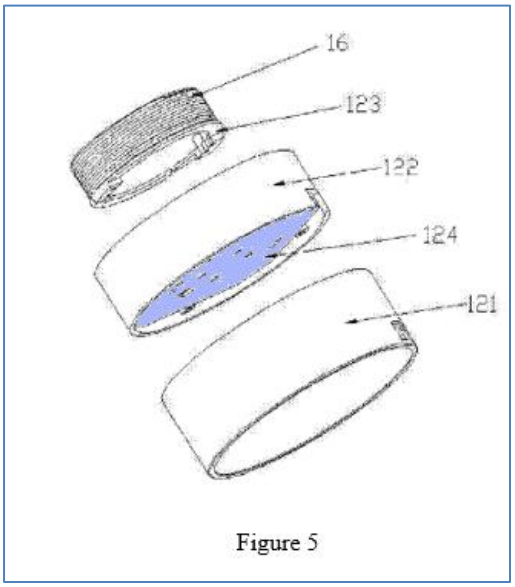
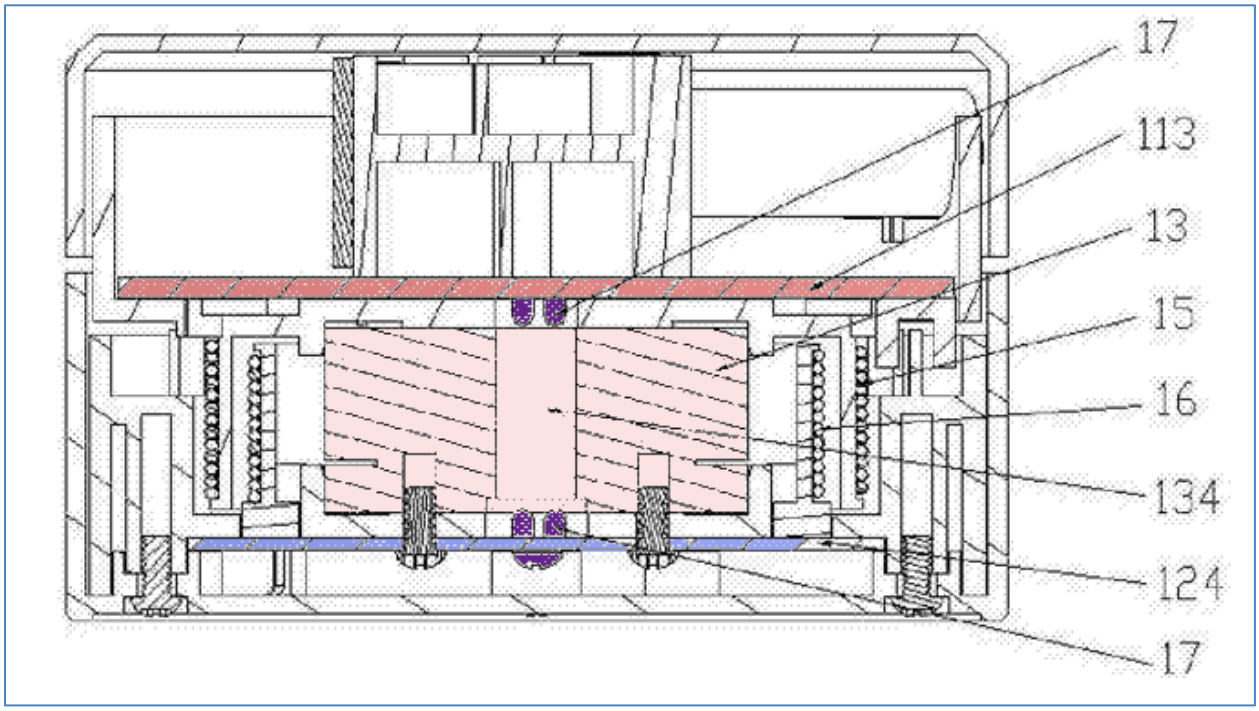


Figure 5

Id., [0025], Figs. 3, 5, Claims 4-5. Specifically, as shown in Figure 3, the rotating disk "includes an upper cover (111), a rotating disk body (112), and a first circuit board (113), and first coil (15) is wound on an annular structure formed at the lower end of the rotating disk body (112)." *Id*. As shown in Figure 5, the base "comprises

a lower cover (121), a base body (122), a coil wrap mechanism (123), and a second circuit board (124), and second coil (16) is wound on the coil wrap mechanism (123)." *Id*.

268. Circuit boards 113 and 124 are also shown in Figure 8 above motor 13:



Id., [0030], Fig. 4, 8.

269. Thus, a POSITA would have understood that in the combined system Cai's "circuit board (124)" and "circuit board (113)" on which the signal transceivers are mounted would be a "third" and "fourth" circuit board, respectively. In particular, when applying the teachings of Cai to Johnson and Pardhan, the "circuit board 124" of Cai would be fixedly coupled to the base (as disclosed in Cai) and positioned below the stator circuit board that is part of the motor. Similarly, the "circuit board (113)" of Cai would be positioned on the upper surface of Pardhan's

support component, such that it is between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane. And because it is included on the support component, it would rotate with the rotor circuit board about the axis of rotation defined by the shaft.

3. Claim 5: The light ranging system of claim 4 wherein the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth circuit board and the enclosure top with the transmit module mounted to a first portion of the ranging device housing and the receive module mounted to a second portion of the ranging device housing directly adjacent to the first portion

270. In my opinion, the Pacala-Johnson-Pardhan-Zhang-Cai combination satisfies the additional limitation of claim 5 for the reasons discussed in Ground 1, Claim 5.

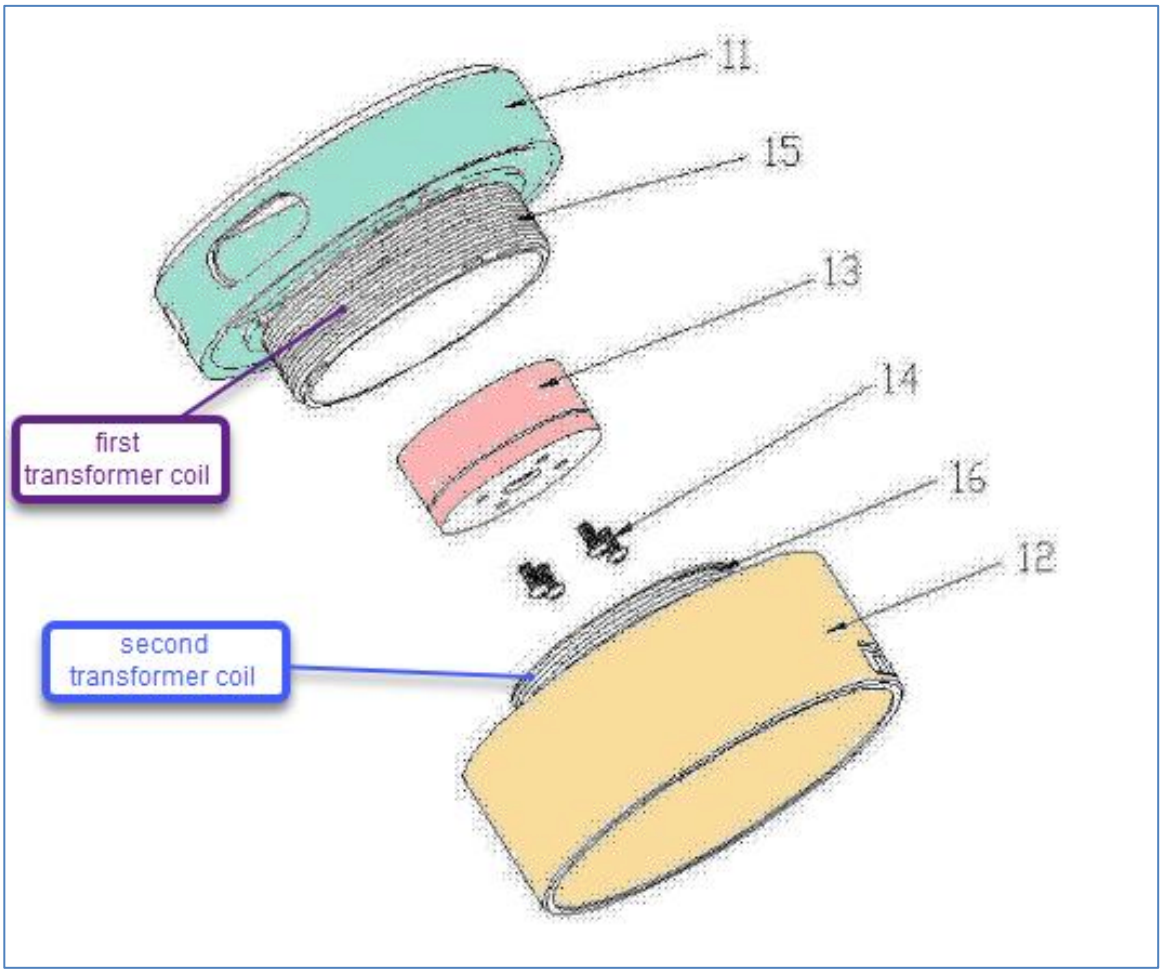
4. Claim 6: The light ranging system of claim 5 wherein transmit module comprises a fifth circuit board with supporting circuitry for the illumination source and the receive module comprises a sixth circuit board with supporting circuitry for the detector circuitry, and wherein the fifth circuit board is mounted to the first housing portion of the ranging device housing and aligned parallel to the axis of rotation and the sixth circuit board is mounted to the second housing portion of the ranging device housing and aligned parallel to the axis of rotation

271. In my opinion, the Pacala-Johnson-Pardhan-Zhang-Cai combination satisfies the additional limitation of claim 6 for the reasons discussed in Ground 1, Claim 6.

5. Claim 17: The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement

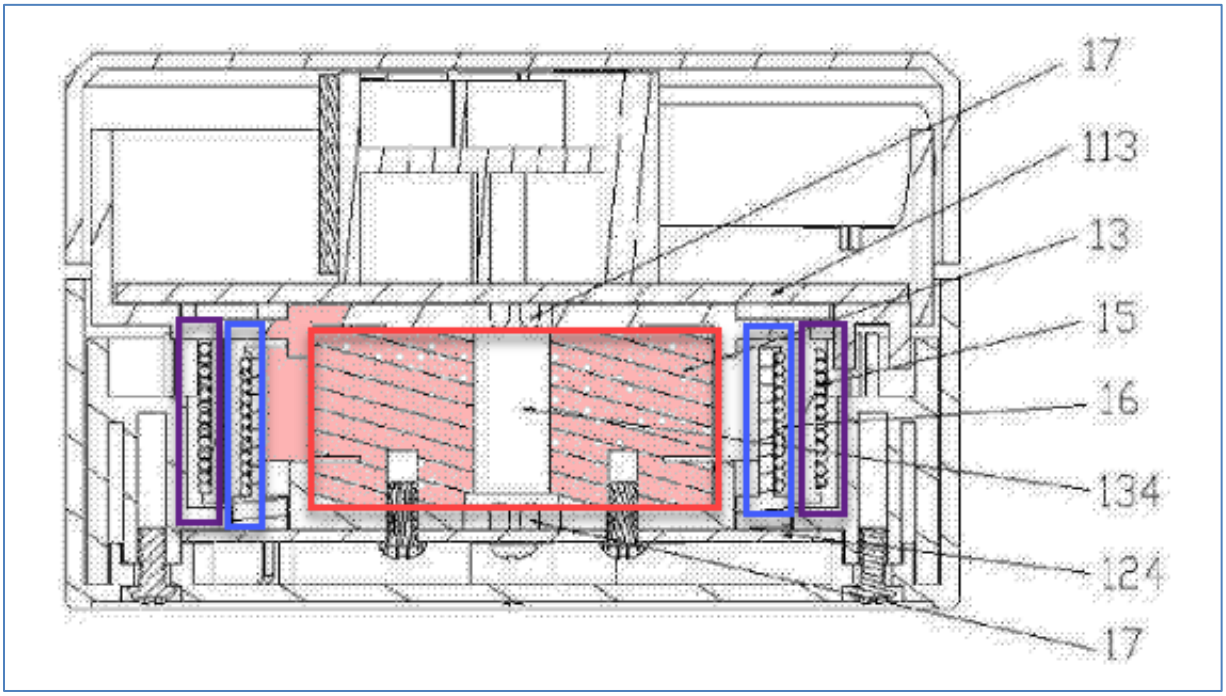
272. As I discussed in connection with Ground 1, Johnson satisfies every aspect of Claim 17, except that it illustrates the first and second annular transformer coils positioned on the inside of the stator elements and rotor assembly annular arrangement of the motor. I also showed that it was obvious based on Johnson alone to position the transformer coils outside an outer perimeter of the rotor assembly annular arrangement.

273. In my opinion, it would have also been obvious in view of Cai, which discloses such an arrangement. For instance, Figure 2 of Cai illustrates a rotary disk (green) and a base (orange), as well as first (purple) and second (blue) transformer coils that are positioned on the outer permitter of the brushless motor (red):



EX1008, [0025], Fig. 2.

274. Figure 8 provides another perspective, again illustrating the transform coils (purple and blue) outside the motor (red):



EX1008, [0030], Fig. 8.

275. Thus, Cai confirms the understanding of a POSITA that the transformer coils may be concentric with and positioned outside an outer perimeter of the motor elements. And I explained above in connection with my analysis of Ground 1, claims 1/14 that a POSITA would have understood that Johnson's stator and rotor circuit boards (and the stator and rotor assemblies mounted on those circuit boards) form a PCB motor, such that application of Cai's teaching to Johnson would result in positioning the first and second transformer coils of Johnson on the outside of the stator and rotor assembly annular arrangement that are bounded by the perimeter of the motor.

6. Motivation to Combine

276. A POSITA would have been motivated to combine Pacala-Johnson-

Pardhan-Zhang for the reasons discussed in Ground 1. A POSITA would have been further motivated to combine the teachings of Cai in the manner I discussed above for at least the reasons below.

277. ***First***, the prior art provides an express motivation to implement Cai's teachings regarding transceiver circuit boards (the third/fourth circuit boards) that are positioned above and below the circuit boards of the motor. Johnson teaches that its system should include communication means for exchanging sensor data. EX1005, Fig. 2. And Cai teaches that implementing these communication means as signal transceivers 17 mounted in the center region of circuit boards that are located above and below a hollow shaft in a motor allows for data to be exchanged through the hollow shaft. EX1008, [0030]. Further, a POSITA would have understood, and Cai confirms, that because the transceiver is mounted in the middle of the circuit board, its position is "guaranteed to be relatively unchanged" when the rotor rotates, "thereby providing reliable signal transmission." EX1008, [0002], [0030]. A POSITA would also understand that forming the communication channel within a hollow shaft helps avoid interference. EX1007, pg. 1 (having space in the hollow shaft "to accommodate a signal transmission structure… prevents mutual interference of signal transmissions systems."). Thus, a POSITA would have been motivated to apply Cai's teachings to Johnson's communication means to provide reliable signal transmission through a hollow shaft.

278. Similarly, certain applications may not be able to fit signal transceivers within the limited space in the center region of a circuit board, such that additional circuit boards above and below the rotor and stator would be an obvious choice for mounting these communication means.

279. ***Second***, the prior art provides express motivations to apply Cai's teachings regarding the positioning of the transformer coils to Johnson. For instance, as I discussed in connection with my analysis of claim 4 in Ground 1, Johnson illustrates its transformer coils within the perimeter of the rotor magnets and motor coils, but states "[o]ther configurations are possible." EX1005, 8:14-15. Thus, a POSITA would have looked to other known configurations. Cai discloses a known configuration in which the transformer coils are located on the outside of the motor.

280. Further, applying Cai's configuration to Johnson was a straightforward design choice. As I discussed in connection with my analysis of Ground 1, a POSITA would have recognized that certain LiDAR systems may not be able to fit transformer coils within the center region of the circuit board (which has limited space) and would therefore need to place transformer coils on the outside of the magnets and motor coils. Cai reinforces this understanding by disclosing one of a limited number of possible configuration in which the transformer coils do not fit in the center region.

7. Reasonable Expectation of Success

281. In my opinion a POSITA also would have had a reasonable expectation of success in combining Cai in the manner I discussed above.

282. A POSITA would have understood that positioning the transformer coils so that they are on the outside of the stator and rotor elements of Johnson would reduce complexity because the transformer coils would not need to be mounted in a small center region of the circuit board. Similarly, power interfaces and transformer coils have long been known and their implementation does not present any novel or unpredictable resolves. And mounting signal transceivers on circuit boards and positioning those circuit boards above and below a motor could be done using basic electrical engineering design principles.

C. Ground 3: Pacala, Johnson, Pardhan, Zhang and Cai in further view of Hall renders obvious Claims 5-6.

283. To the extent Ouster contends that Pacala-Johnson-Pardhan-Zhang-Cai does not render obvious claims 5-6, these claims are at least obvious in further view of Hall, as I discuss below.

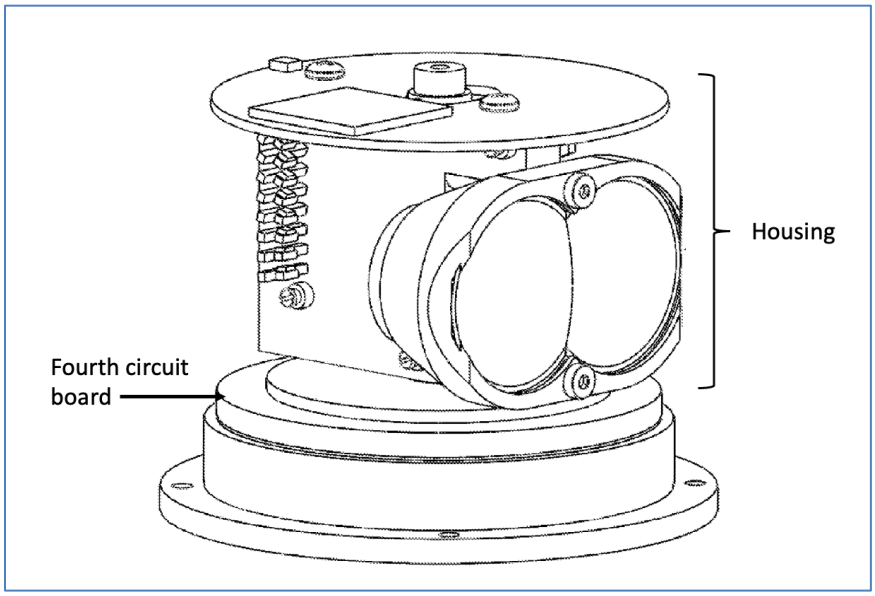
284. Below, I begin by showing how the combined system renders obvious claims 5-6. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.C.3.

1. Claim 5: The light ranging system of claim 4 wherein the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth

circuit board and the enclosure top with the transmit module mounted to a first portion of the ranging device housing and the receive module mounted to a second portion of the ranging device housing directly adjacent to the first portion

285. In my opinion, the Pacala-Johnson-Pardhan-Zhang-Cai-Hall combination satisfies the additional limitation of claim 5.

286. As discussed above, the combination of Pacala-Johnson-Pardhan-Zhang-Cai discloses that the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth circuit board and the enclosure top:

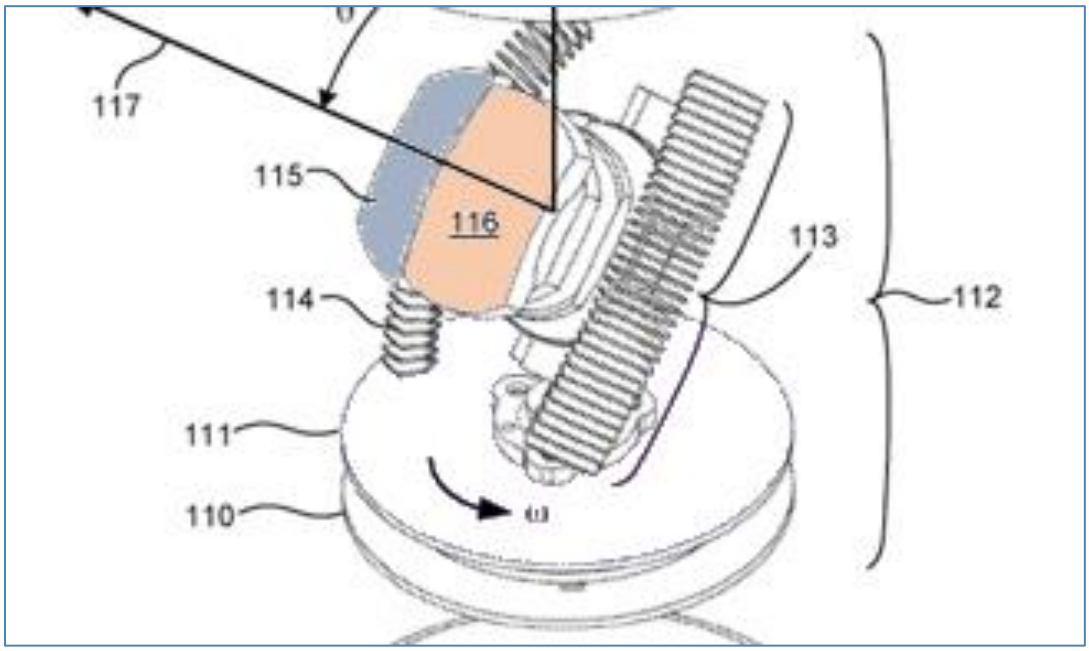


EX1004, Fig. 2. Hall teaches a similar arrangement. EX1009, Fig. 3.

287. Further, as discussed above, Pacala discloses and renders obvious mounting the transmit module to a first portion of the housing and the receive module to a second portion of the housing. To the extent Ouster argues otherwise,

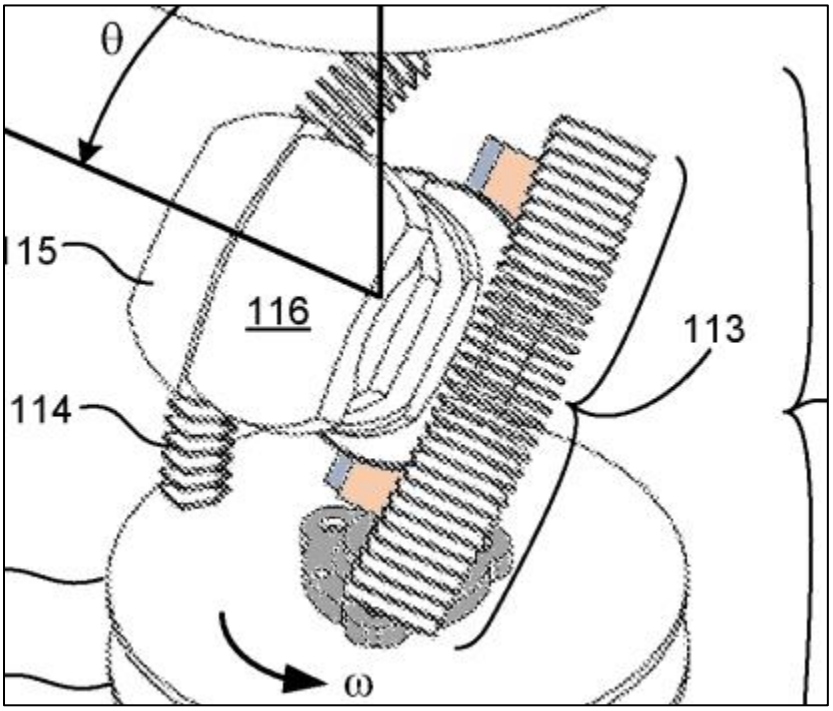
Hall confirms the obviousness of this limitation.

288. Hall provides additional details regarding the internal of the LiDAR sensor and expressly teaches that the LiDAR sensor includes a transmit module that is physically separate from the receive module. For instance, Hall discloses a light emission/collection engine that includes "an array of light emitting elements 114" and "a series of illumination optics 115" (bulk transmitter optic) that "collimate the emitted light into an array of beams" which are emitted from the 3-D LiDAR system into an external field. *Id.*, 4:65-5:5. It also discloses a physically separate collection/detection elements with "collection optics 116" (bulk receiver optic), that collect light reflected from objects in the environment and focus it onto an "array of detecting elements 113." *Id.*, 5:8-14. The bulk transmitter (blue) and receiver (orange) optics are shown below:



Id., Fig. 2; *see also id*., Fig. 4. In the combined Pacala-Hall system, the transmit and receive modules would be mounted within Pacala's LiDAR housing, with the housing continuing to be positioned on the surface of the rotational structure.

289. By the priority date of the '515 patent, enclosing the LiDAR sensor within its own housing was a known technique (*see, e.g.*, EX1004, Fig. 2) and a POSITA would have understood that doing so is desirable because it protects the transmit and receive components from damage (EX1006, 11:47-58). Further, Hall already teaches that the transmit and receive modules should be mounted on the surface of the rotational structure and provides one type of mount (gray) for doing so:



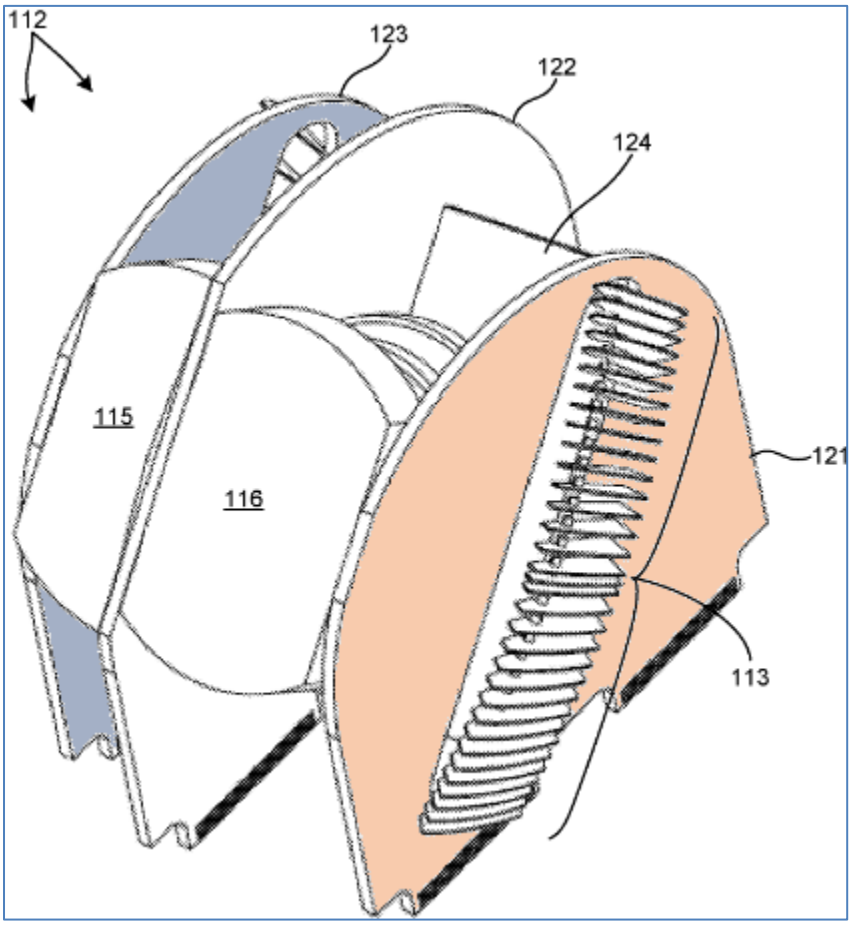
EX1009, Fig. 2; *see also id*., Fig. 3. Thus, mounting the transmit and receive

modules to the rotational structure within Pacala's LiDAR housing would amount to simple substitution of one known element (Hall's existing mount) for another (Pacala's LiDAR housing mount) to obtain predictable results (transmit and receive modules mounted within the LiDAR housing).

2. Claim 6: The light ranging system of claim 5 wherein transmit module comprises a fifth circuit board with supporting circuitry for the illumination source and the receive module comprises a sixth circuit board with supporting circuitry for the detector circuitry, and wherein the fifth circuit board is mounted to the first housing portion of the ranging device housing and aligned parallel to the axis of rotation and the sixth circuit board is mounted to the second housing portion of the ranging device housing and aligned parallel to the axis of rotation

290. In my opinion, the Pacala-Johnson-Pardhan-Zhang-Cai-Hall combination satisfies the additional limitation of claim 6.

291. Hall expressly discloses that the illumination and detector circuitry of the transmit and received modules may be mounted on circuit boards. For instance, Hall teaches that the "light detecting elements 113" are mounted on circuit board 121, while the "light emitting elements 114" are mounted on circuit board 123, as shown below:



Id., Fig. 4, 7:3-24. Hall also discloses that the lower ends of circuit boards 121-123 is positioned on the rotating electronics board, such that the circuit boards extend vertically upwards along the axis of rotation 306. *Id.*, 7:11-16. Thus, in the combined system circuit boards 121 and 123 are each mounted to portions of Pacala's LiDAR device housing, and constitute the claimed "fifth" and "sixth" circuit boards that are aligned parallel to the axis of rotation.

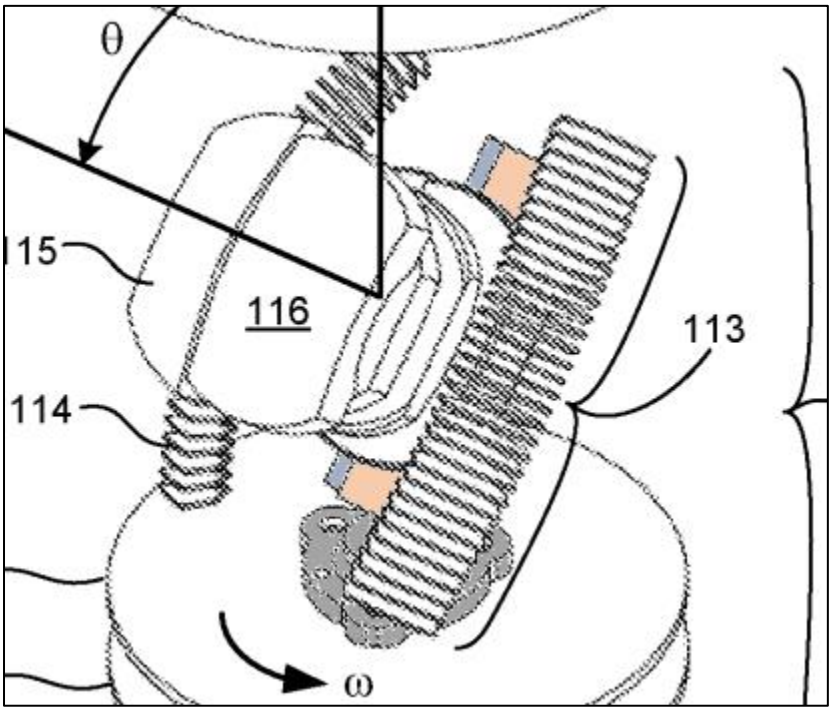
3. Motivation to Combine

292. A POSITA would have been motivated to combine Pacala-Johnson-Pardhan-Zhang-Cai for the reasons discussed in Ground 2. A POSITA would be

motivated to further combine Hall in the manner discussed above for at least the reasons I discuss below.

293. ***First***, while a POSITA would have understood the transmit and receive modules of Pacala would comprise circuit boards mounted to portions of the LiDAR housing. But to the extent Ouster disagrees, a POSITA would look to known configuration for transmit and receive modules and Hall describes a known configuration in which the modules are implemented on separate circuit boards. Further, by the priority date of the '515 patent a LiDAR housing was a known and conventional component (*see, e.g.*, EX1004, Fig. 2) and a POSITA would have understood that mounting the modules in the housing is desirable because it protects the transmit and receive components from damage (EX1006, 11:47-58).

294. ***Second***, mounting the transmit and receive modules to the rotational structure within Pacala's LiDAR housing would amount to simple substitution of one known element for another to obtain predictable results. Hall already teaches that the transmit and receive modules should be mounted on the surface of the rotational structure and provides one type of mount (gray) for doing so:



EX1009, Fig. 2; *see also id.*, Fig. 3. And Pacala discloses that the LiDAR components may be enclosed within a housing when mounted on the rotational structure. Thus, a POSITA would have found it to be a matter of simple substitution to employ Pacala's LiDAR housing, rather than Hall's mount, when mounting the transmit and receive modules to the rotational structure.

4. Reasonable Expectation of Success

295. In my opinion a POSITA also would have had a reasonable expectation of success in further combining Hall in the manner I discussed above.

296. Hall and Pacala discloses well-known arrangements for LiDAR devices. A POSITA would have understood that mounting and positioning circuit boards within a LiDAR housing was straightforward and could be accomplished using basic electrical engineering design principles.

D. Ground 4: Pacala, Johnson, Pardhan, and Zhang in further view of Spector renders obvious Claims 12 and 20.

297. I showed in connection with Ground 1 that Pacala, Johnson, Pardhan, and Zhang render obvious claims 1 and 14. Claims 12 and 20 are obvious in further view of Spector, which discloses the additional limitations of these claims.

298. Below, I begin by showing how the combined system renders obvious claims 12 and 20. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.D.2-3.

1. (Claim 12) The light ranging system of claim 1 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field-of-view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels / (Claim 20) The light ranging system of claim 14 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels

299. Claims 12 and 20 recite the same additional limitation.

300. As I discussed in connection with Limitations 1[i] and 14[j], Pacala

teaches a LiDAR system that includes optical transmitters (emitters) and optical receivers. But Pacala does not discuss the relative fields-of-view of different transmitters and receivers, or the correspondence between these components.

301. Spector, however, discusses these details. "FIG. 1 illustrates a LiDAR system 10." EX1010, 2:65-67. Spector explains that an "arrayed micro-optic" projects "a two-dimensional array of light spots on a scene." *Id.*, Abstract, 3:1-3. Further, Spector states that each light spot is "isolated" from other light spots (*id.*, 6:12-15), and that an aperture array at the receiver optics "limits visibility by each optical detection site to a single corresponding light spot." *Id.*, 3:59-61. Thus, a POSITA would have understood that each isolated light spot corresponds to a non-overlapping field-of-view, such that Spector discloses detector circuitry comprising pixels that each have a non-overlapping field-of-view.

302. Spector also explain that the receiver channels—which include the apertures at the receiver optics and their corresponding optical detection sites—have a "one-to-one correspondence" with the light spots generated by the emitter channels: "an array of optical detection sites are formed in receiver optics 16. The optical detection sites are configured for establishing a one-to-one correspondence between the light spots in the two dimensional array and the optical detection sites. The individual optical detection sites help minimize cross-talk among the reflected light from the spots." *Id.*, 3:34-37; *see also id.*, 3:59-61, 5:33-35, 6:12-15. Thus, a

POSITA would also understand that each paired light spot and its corresponding optical detection site have coincident fields-of-view.

303. Thus, applying the teaching of Spector to the LiDAR device of Pacala results in a system in which the LiDAR device projects discrete beams of light into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field-of-view of one pixel in the plurality of pixels.

2. Motivation to Combine

304. A POSITA would have been motivated to combine Pacala-Johnson-Pardhan-Zhang for the reasons I discussed in connection with Ground 1. A POSITA would have been further motivated to combine the teachings of Spector for at least the reason I discuss below.

305. ***First***, a POSITA would have understood that the teachings of Spector are directly applicable to the LiDAR device of Pacala. As noted above, Spector teaches that its aperture layers improve a conventional LiDAR system by reducing crosstalk and multipath signals. EX1010, 6:12-15. A POSITA would have looked to techniques like the ones disclosed in Spector to improve the performance of Pacala's transmission and detection modules, for example by mitigating known problems associated with signal noise and interference.

306. ***Second***, the prior art teaches an express motivation to apply the

improvements of Spector to the LiDAR device of Pacala. As noted above, Pacala teaches the need to improve the performance of LiDAR devices without making it more susceptible to noise. EX1004, [0003], [0007]. Spector teaches techniques to solve this problem, including the use of aperture arrays to reduce cross-talk and multipath signals. *See* EX1010, 6:12-15. Thus, a POSITA would have been motivated to apply Spector's aperture arrays, to the LiDAR device of Pacala to increase sensitivity while also maintaining accuracy and reliability.

3. Reasonable Expectation of Success

307. In my opinion, a POSITA also would have had a reasonable expectation of success in combining the teachings in these references in the manner I discussed above.

308. ***First***, LiDAR devices had been widely studied and used before the priority date, and the state of the art thus confirms that a POSITA would have had a reasonable expectation of success combining the teachings of Spector with the LiDAR device of Pacala.

309. ***Second***, a POSITA would have similarly understood that Spector's aperture arrays would isolate adjacent detectors and thus reduce cross-talk and multi-path signals that would otherwise be expected when the emitted light spots are reflected. *See* EX1010, 3:37-38. A POSITA would have understood that Spector's improvements could be implemented within a conventional LiDAR device, such as

Pacala's, using basic electrical engineering design principles.

E. Ground 5: Pacala, Johnson, Pardhan, Zhang, and Spector in further view of Droz renders obvious Claims 13 and 21.

310. I showed in connection with Ground 1 that Pacala, Johnson, Pardhan, and Zhang render obvious claims 1 and 14, and I showed in connection with Ground 4 that claims 12 and 20 are obvious in further view of Spector. Additionally, in my opinion claims 13 and 21—which both recite the same additional limitation requiring each pixel comprise a plurality of SPADs—are further obvious in view of Droz.

311. Below, I begin by showing how the combined system renders obvious claims 13 and 21. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.E.2-3.

1. (Claim 13) The light ranging system of claim 12 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) / (Claim 21) The light ranging system of claim 20 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs)

312. Pacala discloses that its optoelectronics components 70 include detector circuitry that can be "integrated into the pixels of a detector array (*e.g.*, Single-Photon Avalanche Diode [SPAD] array)." EX1004, [0012]-[0014]. But Pacala does not discuss details regarding the pixels.

313. Droz provides the additional details and expressly discloses that each

pixel in the plurality of pixels can comprise a plurality of SPADs. Figure 3B of Droz discloses "light detector arrays 310, 316, and 318," and explains that each may correspond to a pixel of a multi-pixel image. EX1011, 13:1-3. For instance, Droz explains that the output from each light detector array "may correspond to an image pixel." *Id.*, 14:37-40; *see also id.*, 4:9-11. Further, Droz explains that each light detector array—which, as just mentioned, corresponds to a pixel in the plurality of pixels—includes "a plurality of light detectors," such as a plurality of "SPADs." *Id.*, 13:3-6, 5:28-29, 18:55-57 ("[T]he array of light detectors comprises a plurality of single photon avalanche diodes (SPADs)."). Thus, a POSITA would have understood that Droz discloses that each pixel in the plurality of pixels may include a plurality of SPADs.

314. Applying this teaching to Pacala, the LiDAR device in the combined system includes a plurality of SPADs "integrated into [each] pixel[]."

2. Motivation to Combine

315. A POSITA would have been motivated to combine Pacala-Johnson-Pardhan-Zhang-Spector for the reasons discussed in Ground 4. A POSITA would have been motivated to further combine the teachings of Droz for at least the reasons discussed below.

316. ***First***, POSITA would have understood that the teachings of Droz are directly applicable to LiDAR devices, including the LiDAR device of Pacala. One

class of improvements in the design of LiDAR devices since Pacala was first filed was to their detection capability. Indeed, Droz reflects that understanding through its teaching of light detector arrays that include a plurality of SPADs for each pixel to improve the sensitivity of the system. A POSITA would have understood that implementing this predictable improvement in Pacala would improve the sensitivity of the light detectors of the light ranging device.

317. ***Second***, Pacala teaches an express motivation to apply the SPAD array of Droz. Pacala states that its detector circuitry can be "integrated into the pixels of a detector array (*e.g.*, *Single-Photon Avalanche Diode [SPAD] array*)." EX1004, [0014]. Droz provides additional details relating the SPAD arrays referred to in Pacala, including that SPAD technology was well-known and that each pixel could include a plurality of SPADs to improve detection capabilities. Thus, a POSITA would have looked to the teachings of Droz when considering how to implement the SPAD arrays disclosed in Pacala and address detection capabilities.

318. ***Third***, a POSITA would have understood that implementing an array of SPADs per pixel is desirable due to the recovery time associated with a SPAD. As the '515 Patent explains, it was known at the time that a "SPAD suffers some deadtime during which external circuitry operates to quench the SPAD so that it is ready to detect again." EX1001, 41:29-46. Similarly, Droz states that once an individual SPAD absorbs a photon, it "cannot detect additional photons until the

SPAD is quenched," which it refers to as the "recovery time." EX1011, 11:2-10. Droz teaches that implementing a plurality of SPADs "enhanc[es] the[] detection qualities" of the system and thus "improve[s] the sensitivity of the system." EX1011, 1:10-23, 3:63-67. Thus, a POSITA would have understood that implementing an array of SPADs, as taught in Droz, addresses the deadtime issue because having multiple SPADs would mean that at least some SPADs are likely to be ready to detect while others may be in recovery time.

3. Reasonable Expectation of Success

319. In my opinion, a POSITA also would have had a reasonable expectation of success in combining the teachings of Droz with the teachings of the references in this ground.

320. ***First***, a POSITA would have been motivated to apply the teachings of Droz, which are directly applicable, to the LiDAR device of Pacala to improve the sensitivity of the light detectors. Droz and Pacala both make clear that SPAD technology had been widely studied and integrated into LiDAR devices before the priority date. EX1011, [0002]; EX1004, [0014]. In fact, Pacala states that its LiDAR may employ SPADs. *Id*.

321. ***Second***, a POSITA would have understood that techniques for integrating SPAD arrays into a known LiDAR device were well-known and predictable. For instance, Droz discloses that by the priority date of the '515 Patent

SPADs could be fabricated out of semiconducting material, such as silicon. EX1011, 1:10-20. A POSITA would have also understood that these designs could be mounted on a printed circuit board and incorporated in a LiDAR device using basic electrical engineering design principles.

322. ***Third***, the '515 Patent concedes that SPAD-based detectors were available and integrated into LiDAR devices by the time of its priority date. EX1001, 2:53-3:11 (teaching that InGaAs technology can be employed with SPAD-arrays to improve quantum efficiency). Although the '515 Patent asserts that integrating SPAD-based arrays with good "quantum efficiency" in "a cost-effective manner" could present challenges, the claims of the '515 Patent do not recite any restrictions relating to quantum efficiency or implementation of the SPAD-arrays. And the specification of the '515 Patent includes only sparse disclosures regarding the implementation of SPAD-arrays—it does not teach how one would overcome the purported problems identified in the specification. Indeed, the disclosures in Droz regarding SPAD-arrays are commensurate or more detailed than those of the '515 Patent.

F. Ground 6: Pacala, Johnson, Pardhan, Zhang, Droz, and Cai in further view of Yan render obvious Claims 22-24.

323. The majority of the limitations in claim 22 correspond to those in claims 1 and 14. I showed in connection with Ground 1 that those limitations are rendered

obvious by Pacala, Johnson, Pardhan, and Zhang. Further, Limitation 22[h] corresponds to the limitation of Claim 17, which I showed in connection with Ground 3 is rendered obvious in further view of Cai. Similarly, Limitation 22[f.ii] corresponds to the additional limitation of claim 13, which I showed in connection with Ground 5 is rendered obvious in further view of Droz. The remaining limitations are disclosed by Yan, such that, in my opinion, the combination of Pacala, Johnson, Pardhan, Zhang, Droz, Cai and Yan render claims 22-24 obvious.

324. Below, I begin by showing how the combined system renders obvious claims 22-24. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.F.4-5.

1. Independent Claim 22:

(a) Limitation 22(a): A light ranging system comprising:

325. Limitation 22[a] is the same as limitation 14[a]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(b) Limitation 22(b): an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure

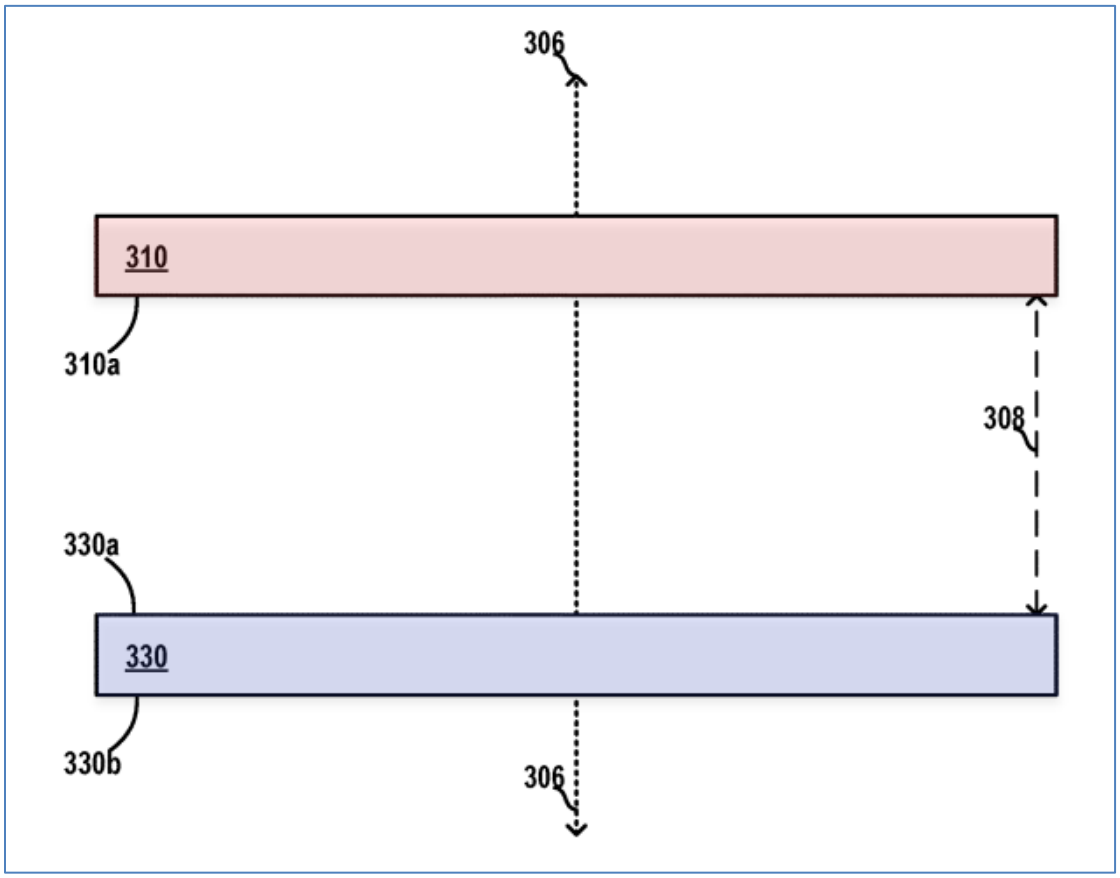
326. Limitation 22[b] is the same as limitation 14[b]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(c) Limitation 22(c): a shaft disposed within the enclosure and defining an axis of rotation, the shaft including a

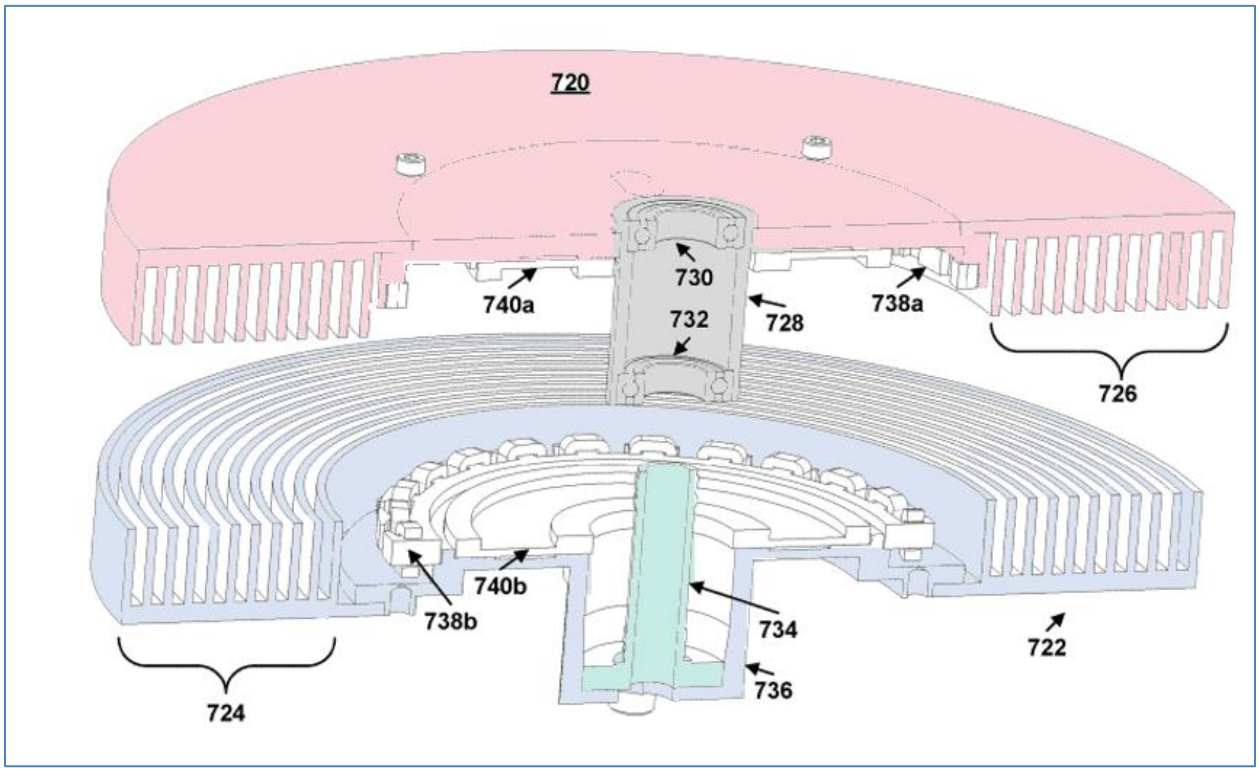
hollow channel axially aligned with the axis of rotation and extending through a length of the shaft

327. Limitation 22[c] recites "a shaft disposed within the enclosure and defining an axis of rotation." This portion of the limitation is the same as Limitation 14[c]. Thus, it is my opinion that this limitation is satisfied for the same reasons.

328. Limitation 22[c] further recites that the shaft includes "a hollow channel axially aligned with the axis of rotation and extending through a length of the shaft." When the teachings of Pardhan are applied to Johnson, this limitation is disclosed for the reasons I discussed in connection with Limitation 14[c]. For instance, Johnson shows a rotor platform 310 (red) which rotates about axis of rotation 306 relative to the stationary stator platform 330 (blue):



EX1005, Fig. 3A; 16:57-17:3. And Pardhan shows a similar structure in which a stator plate (blue) is coupled to a hollow shaft 734 (green) that extends upwards along the vertical axis of rotation (corresponding to axis of rotation 306 in Johnson):



EX1006, 20:40-63, 21:42-45, Fig. 7B.

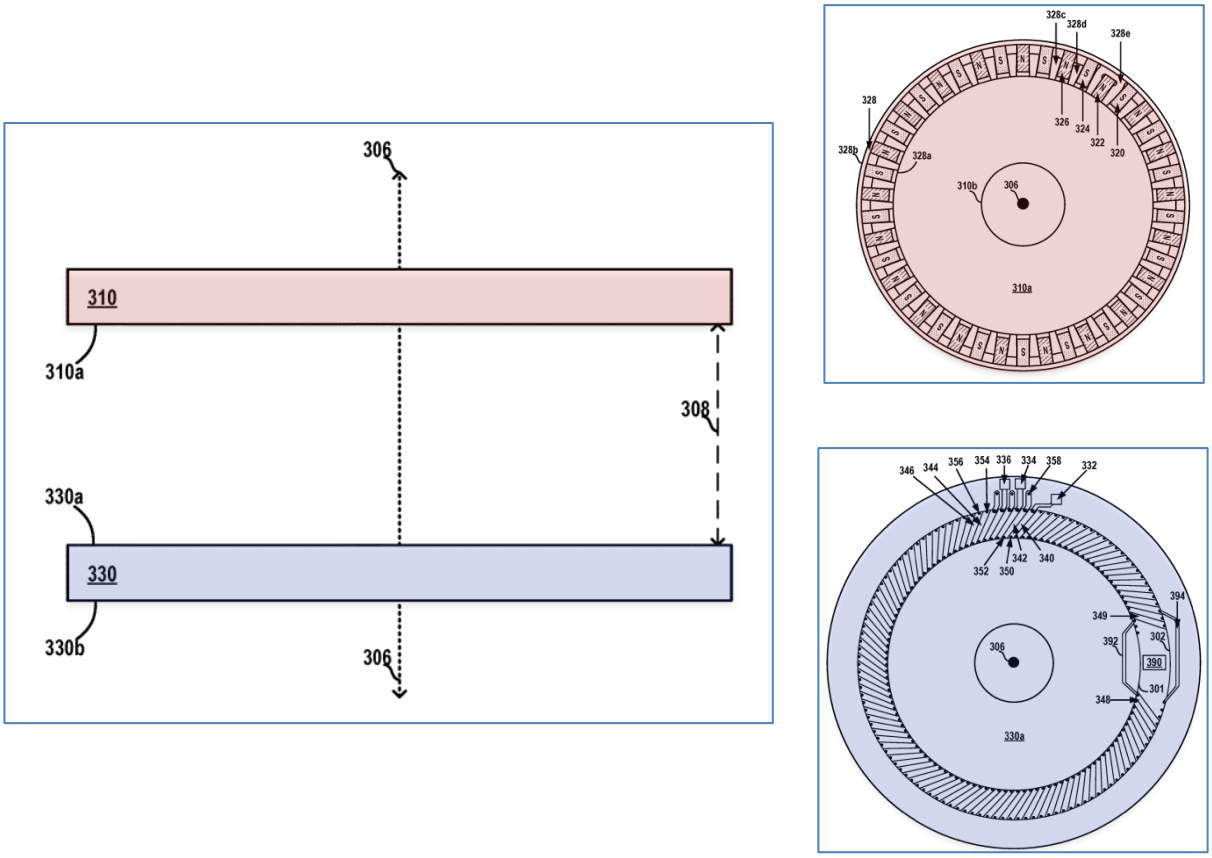
(d) Limitation 22(d): a stator circuit board assembly disposed within and coupled to the enclosure in a fixed relationship, the stator circuit board assembly comprising

329. Limitation 14[d] also recites "a stator circuit board disposed within the enclosure" that is "fixedly coupled to the base of the enclosure." In my opinion, this limitation is disclosed for the same reasons I discussed in connection with Limitation 14[d].

(e) Limitations 22(d.i)-(d.ii): a first circuit board disposed along a plane perpendicular to the axis of rotation; a second circuit board disposed parallel to and adjacent to the first circuit board and having a

first aperture formed through a central portion of the second circuit board

330. The stator circuit board assembly in Johnson includes first and second circuit boards that are parallel and adjacent to one another. The stator platform 330, shown in Figure 3A (left), is a "planar mounting surface" perpendicular to the axis of rotation (306) and has a top (330a) and bottom (330b):



EX1005, 10:58-63, 11:66-12:6, 12:44-67, Figs. 3A, 3C. The stator platform includes a "multi-layer circuit board (*e.g.*, PCB)." *Id*. For instance, Figure 3C (top right) is disposed on the top layer (330a), and Figure 3D (bottom right) is "along a

second layer of the circuit board," *e.g.*, "between sides 330a and 330b," or along bottom side (330b). *Id*., 12:1-6. Thus, each layer (corresponding to a circuit board) is adjacent and parallel to another.

331. Johnson's stator circuit boards also includes an aperture that is formed through a central portion of each layer. For instance, the circuit boards in Johnson are shown to include a "center gap," which can be seen in Figures 3C and 3D (circular white center). EX1005, Figs. 3C-3D; *see also id*., 11:51-52.

332. To the extent Ouster argues that Johnson does not disclose a "first circuit board" and a "second circuit board" because the different layers of the multi-layer circuit board are a single "circuit board," it would have been obvious to implement the layers of the multi-layer PCB using separate circuit boards for the reasons I discussed above in connection with my analysis of Ground 1, Claim 4.

(f) Limitation 22(d.iii): a stator assembly comprising a plurality of stator elements arranged about the axis of rotation

333. Limitation 14[h] also recites "a stator assembly… comprising a plurality of stator elements arranged annularly about the axis of rotation." Thus, in my opinion this limitation is disclosed for the same reasons I discussed in connection with Limitation 14[h].

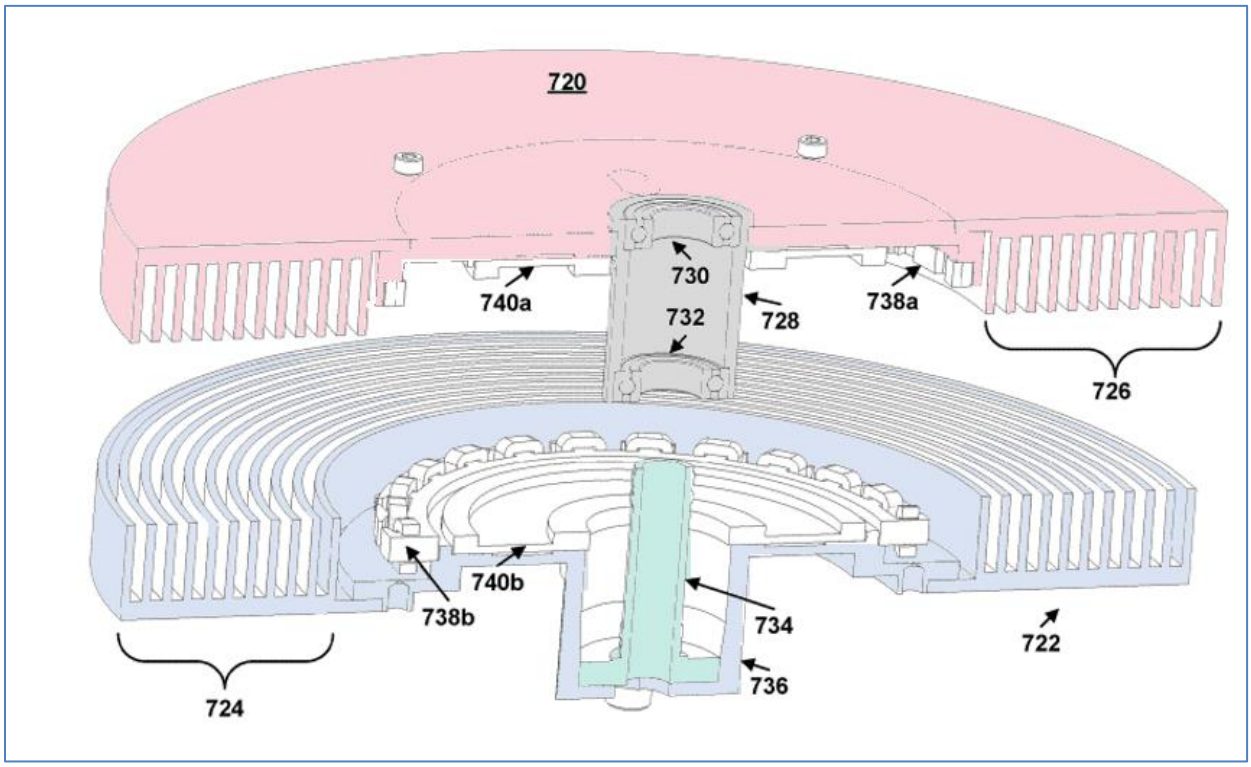
(g) Limitation 22(e): a rotor circuit board assembly disposed within the enclosure and rotationally

coupled to the shaft, the rotor circuit board assembly comprising

334. Limitation 14[g] recites "a rotor circuit board coupled to rotate with [a] support component and disposed within the enclosure." And Limitation 14[e] recites "bearings coupled between the shaft and the support component allowing the support component to rotate around the axis of rotation." Thus, in my opinion this limitation is disclosed for the same reasons I discussed in connection with Limitations 14[g] and 14[e].

(h) Limitation 22(e.i): a support component having lower and upper surfaces, a sleeve extending away from the lower surface and fitted over the shaft, a plurality of arms extending away from the sleeve, and a plurality of alignment posts extending away from the upper surface

335. As I explained in my analysis of Limitation 14[c] and 14[e], Pardhan includes a support component (red and grey) that includes a lower surface (underside of plate 720) and a upper surface (top side of plate 720), as well as a sleeve (728) that extends away from the lower surface and is fitted over the shaft (green):

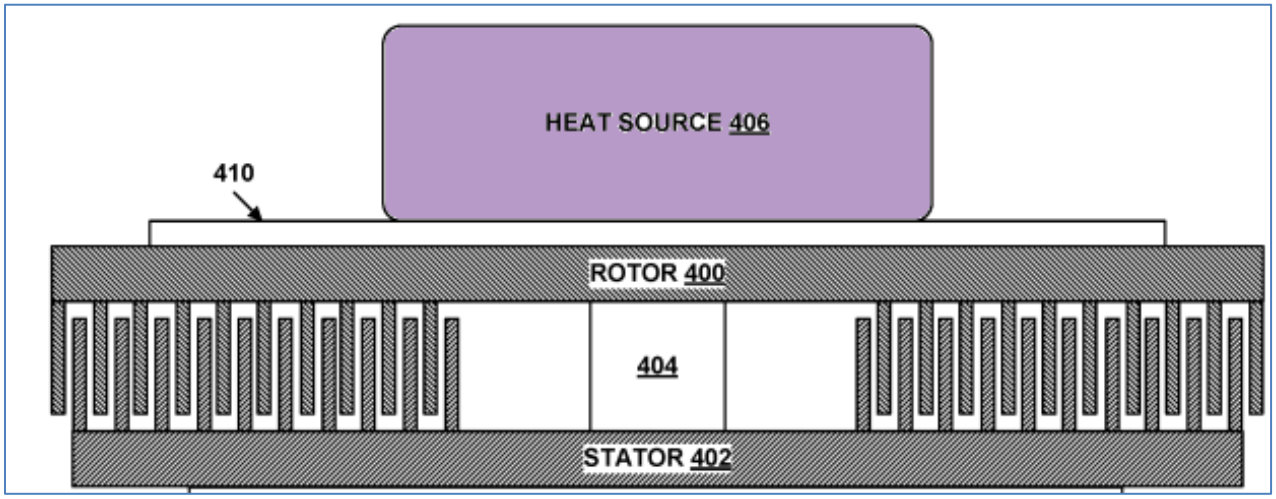


EX1006, Fig. 7B. Further, Pardhan when combined with the knowledge of a POSITA or Zhang renders obvious that the support component includes arms extending away from the sleeve, as discussed in connection with Limitation 14[e].

336. It is also my opinion that the teachings of Pardhan alone or in combination with Zhang renders obvious a plurality of alignment posts extending away from the upper surface. Pardhan illustrates the upper surface of the support component having "mounting holes" for mounting the sensing device (*e.g.*, LiDAR). EX1006, 17:55-62, Fig. 5A (showing mounting holes 510a-d). The mounting holes teach or render obvious the claimed "plurality of alignment posts" because a POSITA would have understood that alignment posts are complimentary and used with mounting holes. *See* Section VI.F.

337. If Ouster contends that Pardhan's disclosures do not teach or suggest alignment posts, it is still my opinion that this limitation is obvious. A POSITA would have found it obvious to include alignment posts on the upper surface of the support component for many reasons.

338. *First*, implementing alignment posts was obvious in view of the knowledge of a POSITA. Pardhan discloses that a heat source (purple), such as "LIDAR," may be directly or indirectly coupled to the upper surface of rotor 400 (support component):



EX1006, 16:65-17:5, Fig. 4. By the priority date of the '515 Patent, alignment posts were a known technique for ensuring alignment between components, as I discussed above in Section VI.F. A POSITA would have understood that it is important for a LiDAR sensor to be correctly aligned and would have found it obvious to apply the known technique of using alignment posts to ensure that the LiDAR device is correctly aligned on the upper surface of the support component.

The resulting system would continue to operate in the same manner with the alignment posts ensuring proper positioning of the LiDAR.

339. *Second*, implementing alignment posts was also obvious in view of Yan, in my opinion. Figure 2 of Yan illustrates alignment posts (green) that extend from Yan's support component (red) to ensure the controller circuit board of the ranging device (orange) is properly aligned on the support component using the alignment cutouts (boxes):

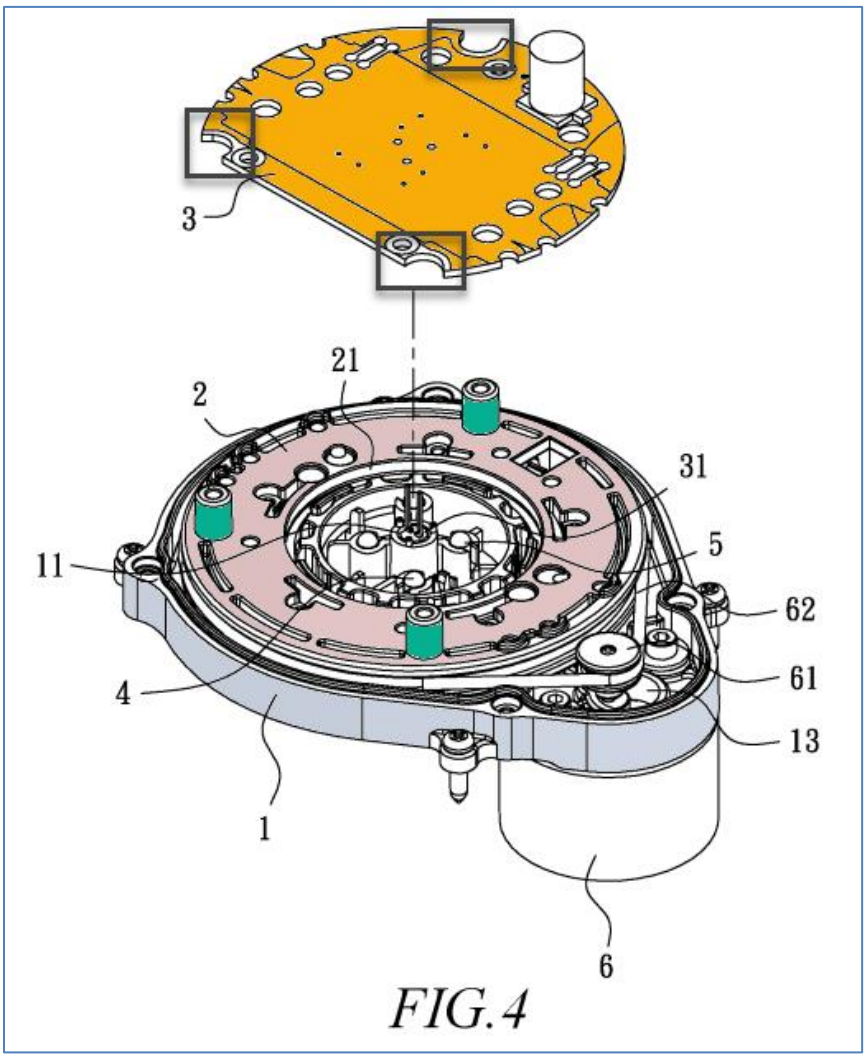
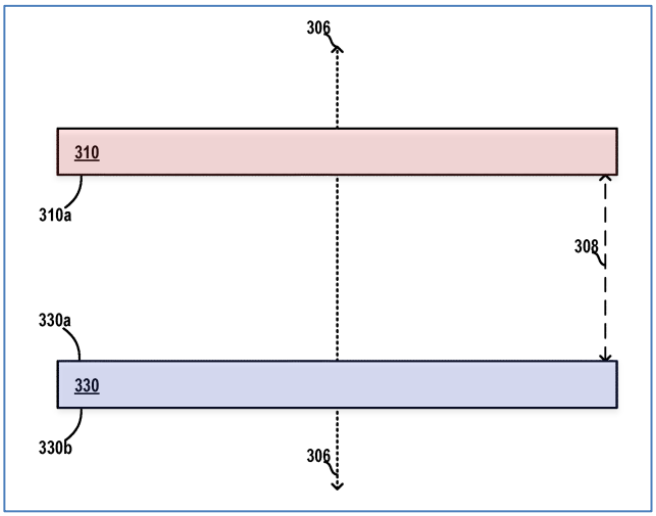


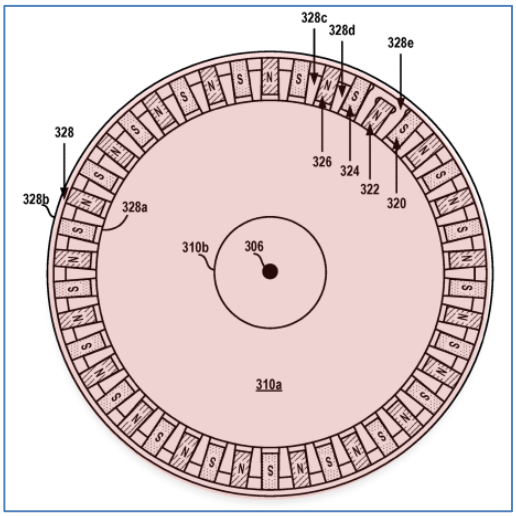
FIG.4

EX1012, [0005]-[0007], [0068], [0070]-[0071]. Thus, a POSITA would have also found it obvious to apply alignment posts to the rotor surface of Pardhan in the same way, so as to properly align the lower portion of the LiDAR device and/or its control circuitry. This understanding is further reinforced by Pardhan's teaching that "mounting holes" 510a-d may be used to mount the LiDAR device (EX1006, 17:55-62, 4:52-53, 5A, 6A) because a POSITA would have understood that mounting holes often refer to a hole that a structure, such as an alignment post, may be fitted into. *See, e.g.*, Section VI.F; *see also* EX1037, 6:39-45, (disclosing that "mounting holes 500, 510" are positioned about "locating posts 250, 260"), 10:37-58, Fig. 2A.

(i) Limitation 22(e.ii): a third circuit board coupled to the lower surface of the support component and disposed adjacent to and in an opposing relationship with the second circuit board

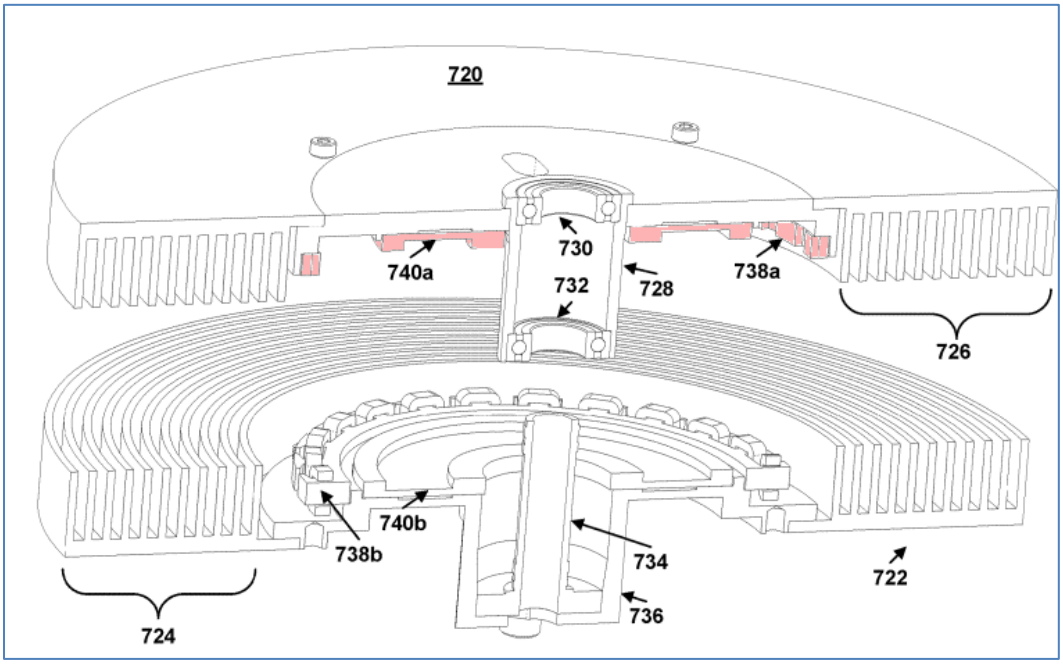
340. Johnson discloses a "third circuit board." For instance, Figure 3B (right) of Johnson illustrates an "an outer layer of a circuit board" that is on a underside (side 310a) of the rotor platform:





EX1005, Figs. 3A-3B, 10:58-62. The PCB layer in Figure 3B is a "third circuit board," in my opinion.

341. Further, as I discussed in connection with limitation 14[g], it was obvious to mount this rotor circuit board to the bottom of Pardhan's support component:



EX1006, Fig. 7B. Thus, the "third circuit board" in the combined system is coupled to a lower surface of the support component.

342. Further, as I discussed in connection with Limitation 22[d.ii], the stator circuit board of Figure 3C may be disposed on the top side of the stator platform (330a). Figure 3C is a second circuit board and because it is disposed on the top side of the stator platform, while Figure 3B is disposed on the bottom side of the rotor platform, Johnson teaches a second circuit board (Fig. 3C) and a third circuit board (Fig. 43) are disposed adjacent to and in an opposing relationship with one another. EX1005, 16:63-65, 17:10-14, 18:24-28, Fig. 3A. Figure 7B of Pardhan also confirms that the rotor and stator are in an opposing relationship. EX1006, Fig. 7B (above).

(j) Limitation 22(e.iii): a fourth circuit board coupled to the upper surface of the support component and arranged parallel with the third circuit board between the third circuit board and the top cover, the fourth circuit board having a plurality of alignment cutouts sized and shaped to accept the alignment posts

343. As I discussed in connection with Limitation 22[e][ii], Figure 3B of Johnson discloses a "third circuit board" that is mounted on the lower surface of Pardhan's support component in the combined system.

344. Johnson also renders obvious a fourth circuit board. For instance,

Johnson discloses that various electronic component may be mounted on the rotor platform. EX1005, 7:2-47, Fig. 2. A POSITA would have understood that space on a circuit board is finite, such that in some applications multiple circuit boards are needed to accommodate the electronics. Indeed, Johnson refers to Figure 3B of the rotor platform as an "outer layer of a circuit board," suggesting that inner layers can also be implemented, and further states that the elements of its system may be provided in "any suitable combination and location" (*id*., 19:66-20:4). Pardhan similarly explains that the LiDAR device may include "various types of electronics and components" and that the electronics "may be disposed within the LiDAR device in any feasible manner." EX1006, 6:35-41; *see also id*., 6:6-16 (showing LiDAR device 100 includes the rotating and stationary platforms). And as I showed in connection with Ground 1, Claim 4, other prior art references that reflect the understanding of a POSITA confirm that "further circuit boards" may be employed in a LiDAR system to provide additional "space and capacity" for mounting system electronics. EX1043, 6:1-8 ("more circuit board can be provided" for "sufficient space and capacity."), 2:62-3:3 ("It is additionally conceivable to provide at least one further circuit board…"); *see also* Section IX.A.4. Thus, a POSITA would have understood Johnson to teach or suggest that in some embodiments electronics could be disposed on a fourth circuit board.

345. It was also obvious to mount a fourth circuit board on the upper surface

of the support component. The possible locations for circuit boards of the rotor platform are finite (on the top side or on the bottom side), such that a POSITA would at once recognize both options. Thus, a POSITA would have found it obvious to try mounting electronics of the LiDAR system—*e.g.*, processors and controllers for operating sensor 212 or communication interfaces—on a PCB coupled to the upper side of the support component.

346. For instance, as I showed in connection with Ground 3, Cai provides an example in which signal transceivers are mounted on circuit boards that are positioned above and below the circuit boards containing the rotor and stator elements of the PCB motor in a configuration that improves the "reliabil[ity] [of] signal transmission" by "guaranty[ing]" the positions of the transceivers remain "relatively unchanged" and allowing for communication through the hollow shaft at the center of the motor. EX1008, [0002], [0030]. Thus, Cai also confirms that it was obvious to provide a circuit board on the top surface of the support component and rotate it with the ranging device.

347. Yan similarly discloses mounting a fourth circuit board on the upper surface of the support component. Indeed, Johnson discloses that control circuitry (*e.g.*, a processor and controller 214) for operating a ranging device 212, which may be "LIDAR," can be mounted on a circuit board, and Yan teaches that the control circuitry for a ranging device (orange) may be mounted on the top surface of a rotor

plate (the support component) with alignment cutouts (boxes) sized and shaped to accept alignment posts (green), as shown below:

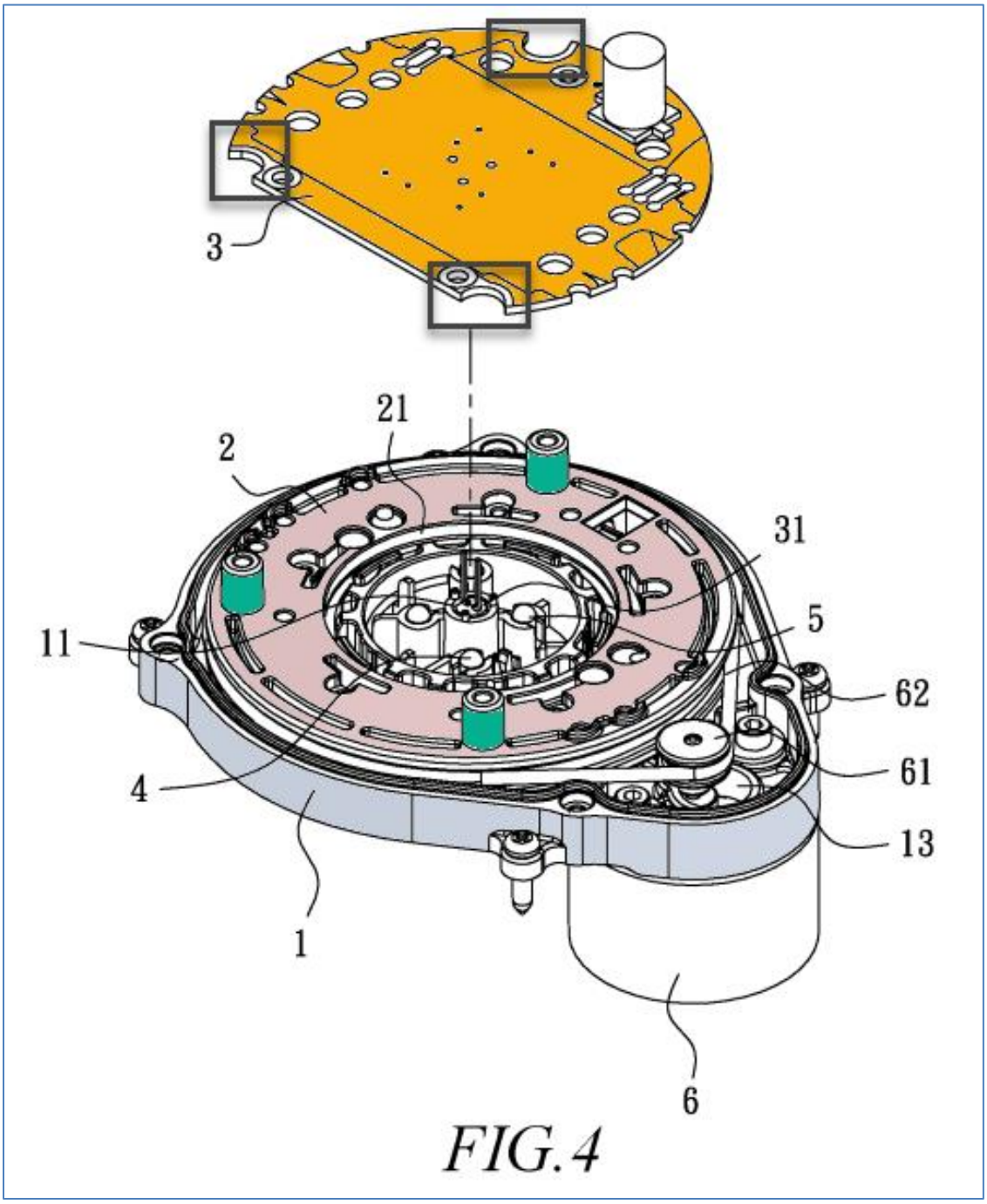


FIG. 4

EX1012, Fig. 4. Thus, a POSITA would have found it obvious to apply Yan's teaching to mount control circuitry for Pacala's ranging device on the top surface of the support component. The control circuitry would be a fourth circuit board.

(k) Limitation 22(e.iv): a rotor component coupled to the rotor circuit board assembly and spaced apart from and concentric with the stator assembly, the rotor component comprising an annular arrangement in which a plurality of magnetic segments surround the axis of rotation and are distributed along the annular arrangement in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles

348. Limitation 14(i) recites "a rotor assembly coupled to the rotor circuit board, the rotor assembly including an annular arrangement in which a plurality of magnetic poles surround the axis of rotation in an alternating pattern such that each magnetic pole has a polarity opposite a polarity of its adjacent magnetic poles." Limitation 22(e.iv) is disclosed for the same reasons I discussed in connection with Limitation 14(i).

(l) Limitation 22(f.i): a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module and a receive module, the transmit module comprising a bulk transmitting optic and a light source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, the receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the

electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment

349. Limitation 14(j) recites "a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment." Limitation 22(f.i) is disclosed for the same reasons I discussed in connection with Limitation 14(j).

(m) Limitation 22(f.ii): wherein the detector circuitry comprises a plurality of pixels, each pixel comprising a plurality of single photon avalanche detectors (SPADs) and

350. Claim 13 recites that "each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs)." Limitation 22(f.ii) is disclosed for the same reasons I discussed in connection with claim 13.

(n) Limitation 22(f.iii): wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the light source and the detection of reflected portions of

the electromagnetic radiation pulses by the detector circuitry

351. Claim 19 recites "the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the illumination source and the detection of reflected portions of the electromagnetic radiation pulses by the receive circuitry." Limitation 22(f.iii) is disclosed for the same reasons I discussed in connection with claim 19.

(o) Limitation 22(g): a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on the rotor component to drive a rotation of the second circuit board assembly and the light ranging device about the shaft

352. Limitation 14(k) recites "a stator driver circuit disposed within the enclosure and configured to provide a drive signal to the plurality of stator elements, thereby imparting an electromagnetic force on rotor assembly to drive a rotation of the rotor circuit board and the light ranging device about the shaft." Limitation 22(g) is disclosed for the same reasons I discussed in connection with Limitation 14(k)

(p) Limitation 22(h): a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the

first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with and positioned outside an outer perimeter of the rotor assembly annular arrangement

353. Limitation 22[h] is the same as the additional limitation of Claim 17. Thus, it is my opinion that this limitation is satisfied for the same reasons.

(q) Limitation 22(i): a communication channel extending through the hollow channel in the shaft and operatively coupled to allow ranging data from the light ranging device to be transmitted to circuitry disposed within the enclosure in a fixed relationship to the stator circuit board assembly

354. The additional limitation of claim 2 recites "a communication channel that extends through the hollow shaft allowing ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure in a fixed relationship to the stator circuit board." Limitation 22(i) is disclosed for the same reasons I discussed in connection with the additional limitation of claim 2.

2. Claim 23: The light ranging system of claim 22 wherein the plurality of stator elements and the annular arrangement of the plurality of magnetic segments are each disposed between a surface of the second circuit board and a surface of the third circuit board

355. As I showed in connection with Limitations 14[d] and 14[g], Johnson discloses a first circuit board (stator circuit board) that includes the plurality of stator elements and a second circuit board (rotor circuit board) that includes the plurality

of magnetic segments. Further, I showed that the stator elements are mounted on the stator circuit board facing upwards, while the magnetic segments are mounted on the rotor circuit board facing downwards. Thus, the plurality of stator elements and the annular arrangement of the plurality of magnetic segments are each disposed between a surface of the second circuit board and a surface of the third circuit board for the reasons I discussed in connection with those limitations.

3. Claim 24: The light ranging system of claim 22 wherein each magnetic segment in the annular arrangement of the rotor component comprises a permanent magnet

356. The additional limitation of Claim 7 recites that "the annular arrangement comprises a plurality of separate permanent magnets."

357. I understand that in the ITC action, which has now been terminated, the parties have proposed constructions of the term "magnetic segment," which appears in this limitation. I understand that no construction has been adopted by the ITC. I understand that the ITC Staff proposed that the term should be given it "plain and ordinary meaning, for example, a plurality of magnets." EX1020. I understand that Ouster proposed that the term should be construed as "more than one magnetic segment." EX1021. And I understand that Hesai proposed that the term should be construed as "two or more individual magnets." EX1022. The prior art discloses a "magnetic segment" that comprises a plurality of individual magnets, such that it would satisfy all of these constructions. For example, I showed in connection with

Ground 1, Claim 7 that Johnson discloses a rotor circuit board on which an annular arrangement of permanent magnets are mounted.

4. Motivation to Combine

358. A POSITA would have been motivated to combine Pacala-Johnson-Pardhan-Zhang-Cai-Droz for the reasons discussed in Grounds 1, 2 and 5. A POSITA would be motivated to further combine Yan in the manner discussed above for at least the reason I discuss below.

359. ***First***, a POSITA would have also been motivated to align control circuitry of a ranging device that is mounted on the upper surface of a support structure using alignment posts. A POSITA would have understood that proper alignment is important to achieving accurate and reliable measurements in a ranging device. By the priority date of the '515 Patent, alignment posts were commonly used to assure alignment between components, such as control circuitry and a rotating support structure to which it mounted. *See* Section VI.F. Thus, use of alignment posts to attach control circuitry of a ranging device, as taught in Yan, merely reflects the use of a known technique to improve similar devices (rotating ranging devices), in the same way (the alignment posts provide correct alignment on the upper surface of the support structure).

360. ***Second***, a POSITA would also understand that to achieve accurate and reliable measurements from a ranging device proper alignment is important. In fact,

Pardhan discloses mounting holes 510a-d that are used to attach a light ranging device and its control circuitry. EX1006, 17:55-62. A POSITA would have understood that alignment posts and mounting holes are complimentary. EX1038, 10:37-58 ("The cooperation of… the locating posts 250, 260, and the sensor assembly mounting holes 500, 510 ensure that the Hall devices 530 are oriented in a known position with respect to the stator assembly 140."). Thus, Pardhan provides an express motivation to apply alignment posts mounted to the upper surface of the support structure for purposes of aligning a light ranging device and its circuitry on the upper surface.

5. Reasonable Expectation of Success

361. In my opinion, a POSITA also would have had a reasonable expectation of success in combining the teachings of the references in the manner I discussed above. Alignment posts have been employed to provide precise alignment using conventional assembly techniques for decades, as I have already explained. A POSITA would have understood that components of a ranging device, such as the control circuitry, can be aligned onto a rotor surface using alignment posts by applying known engineering and assembly techniques. *See* Section VI.F.

G. Ground 7: Pacala, Johnson, Pardhan, Zhang, Droz, Yan, and Cai in further view of Spector render obvious claim 25.

362. As I showed in connection with Ground 6, Pacala, Johnson, Pardhan, Zhang, Droz, Yan, and Cai render obvious claim 22. Claim 25 further recites: "The

light ranging system of claim 22 wherein the light source comprises a plurality of emitters configured to project a plurality of illuminating beams in a field ahead of the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of pixels." Spector discloses the additional limitation of claim 25.

363. Spector explains that its system is directed at LiDAR and may use an "arrayed micro-optic" in order to "project a two-dimensional array of light spots on a scene." EX1010, 3:1-3. Spector further teaches that the light spots are "focused on the individual optical detection sites." *Id*., 3:38-41. In particular, the apertures "limit[] visibility by each optical detection site to a single corresponding light spot." *Id.*, 3:59-61. A POSITA would thus understand that Spector's implementation would result in an emitted illumination pattern that substantially matches the size and geometry of a plurality of non-overlapping fields-of-view of the plurality of pixels across a range of distances from the system.

364. A POSITA would have been motivated to combine the teachings of Spector with the LiDAR device of Pacala and would have had a reasonable expectation of success for the reasons discussed in Ground 4.

H. Ground 8: Johnson, Pardhan, and Zhang in further view of Pacala-2017 renders obvious claims 1, 2, 4-9, 11-14, 16-17, 19-21.

365. I showed in connection with Ground 1 that Pacala, Johnson, Pardhan, and Zhang render obvious claims 1 and 14. For Limitations 1(i) and 14(j), which are directed at the "light ranging device," I relied upon Pacala in Ground 1. However, in my opinion, these limitations are also obvious in view of Pacala-2017, which discloses a LiDAR device that is similar to that disclosed in the '515 patent. Similarly, dependent claims 5-6, 8, 12-13, and 20-21 are also directed at additional limitations that are disclosed by Pacala-2017. And claims 2, 4, 7, 9, 11, 16-17, and 19 are disclosed by the rotor-stator structure of Johnson-Pardhan-Zhang. Thus, in my opinion, Johnson-Pardhan-Zhang-Pacala-2017 render claims 1, 2, 4-9, 11-14, 16-17, 19-21.

366. Below, I begin by showing how the combined system renders obvious claims 1, 2, 4-9, 11-14, 16-17, 19-21. I then discuss additional reasons why a POSITA would have been motivated to combine the teachings of these references. Sections IX.H.13-14.

1. Independent Claims 1 and 14

(a) Limitation 1(b)/14(b): an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure

367. I showed in my analysis of Ground 1 that Limitations 1(b) and 14(b)

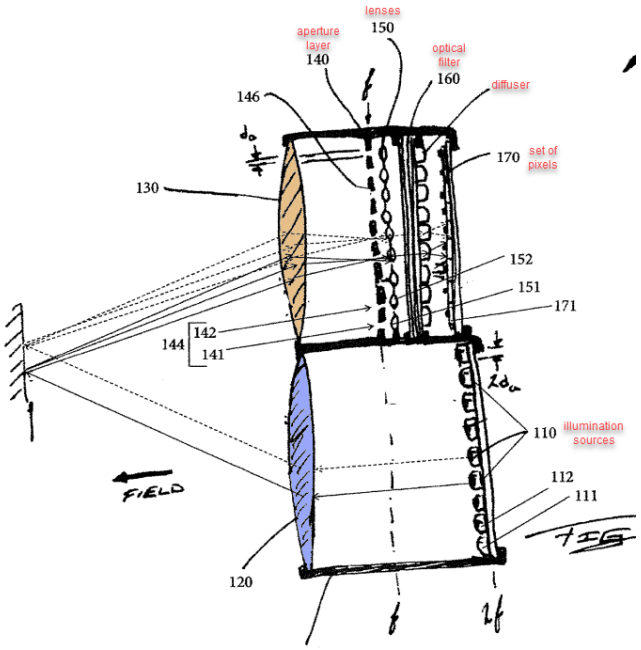
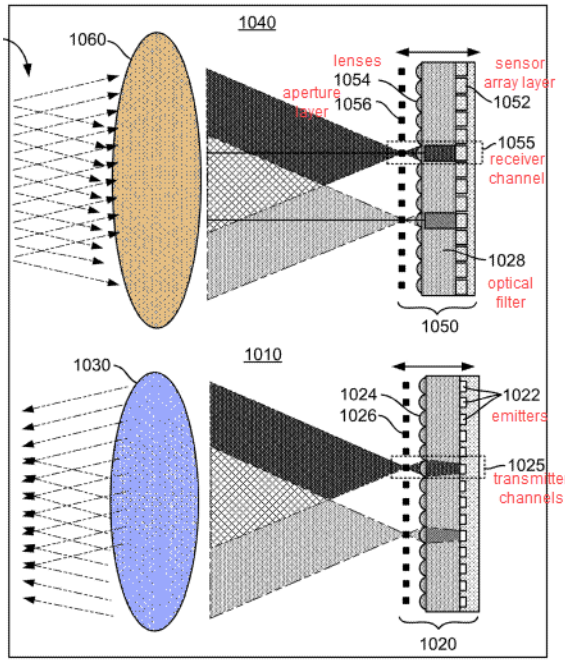
were disclosed by Pacala. Pardhan also discloses this limitation. For instance, Pardhan discloses that the light ranging system is within an enclosure having a base and a top cover. EX1006, 6:6-16, Figs. 1, 7A. Pardhan also discloses that the enclosure can have an optically transparent window extending fully around a periphery of the enclosure. Ex1006, 11:52-58 ("if the housing 122 were to be stationary as the LIDAR device 100 rotates within the housing 122, then the housing 122 would likely be transparent so as to allow for propagation of light through the housing 122 and thus for scanning of the environment by the LIDAR device 100."). Thus, in my opinion Limitations 1(b) and 14(b) are disclosed by Pardhan.

(b) Limitations 1(i)/14(j): a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module comprising a bulk transmitting optic and an illumination source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, and an receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment

368. As I showed in my analysis of Ground 1, Johnson, Pardhan and Zhang render obvious Claims 1 and 14, including Limitations 1(i) and 14(j), both of which recite the same limitation. In my opinion, Limitations 1(i) and 14(j) are disclosed by Pacala-2017, such that claims 1 and 14 are also obvious in further view of Pacala-

2017.

369. For instance, Pacala-2017 teaches that its light ranging device is "rotated about an axis" and includes the claimed "transmit module" and "receive module." EX1013, [0015]-[0016], [0025], Figs. 1-2. The transmit and receive modules include a "bulk transmitting optic" (blue) and "bulk receiver optic" (orange), as shown in Figure 1 below. *Id*. The light ranging device of Pahala-2017 is substantially similar to the '515 Patent, as shown by the comparison below:

Pacala-2017, Fig. 1	**'515 Patent, Fig. 10**
	

Compare id., [0015]-[0018], [0056], Fig. 1 (left) *with* EX1001, 36:35-39:19, Fig. 10 (right); EX1046, 12-16, 19. Thus, in my opinion, Pacala-2017 discloses Limitations 1(i) and 14(j) in the same way as the '515 Patent.

(c) Remaining Limitations of Claims 1 and 14

370. The remaining limitations of claims 1 and 14 are the same ones I analyzed in connection with Ground 1. Thus, it is my opinion that Johnson, Pardhan and Zhang satisfy these limitations for the reasons I discussed above.

2. Claim 2: The light ranging system of claim 1 wherein the shaft is hollow and the system further comprises a communication channel that extends through the hollow shaft allowing ranging data from the light ranging device to be transmitted to processing circuitry disposed within the enclosure in a fixed relationship to the stator circuit board

371. The Johnson-Pardhan-Zhang-Pacala-2017 combination discloses claim 2 for the reasons I discussed in my analysis of Ground 1, Claim 2.

3. Claim 4: The light ranging system of claim 1 further comprising: a third circuit board fixedly coupled to the base and arranged in a plane parallel with the first plane and disposed between the enclosure base and the stator circuit board; and a fourth circuit board coupled to rotate with the rotor circuit board between the enclosure top and the rotor circuit board and arranged in a plane parallel with the first plane

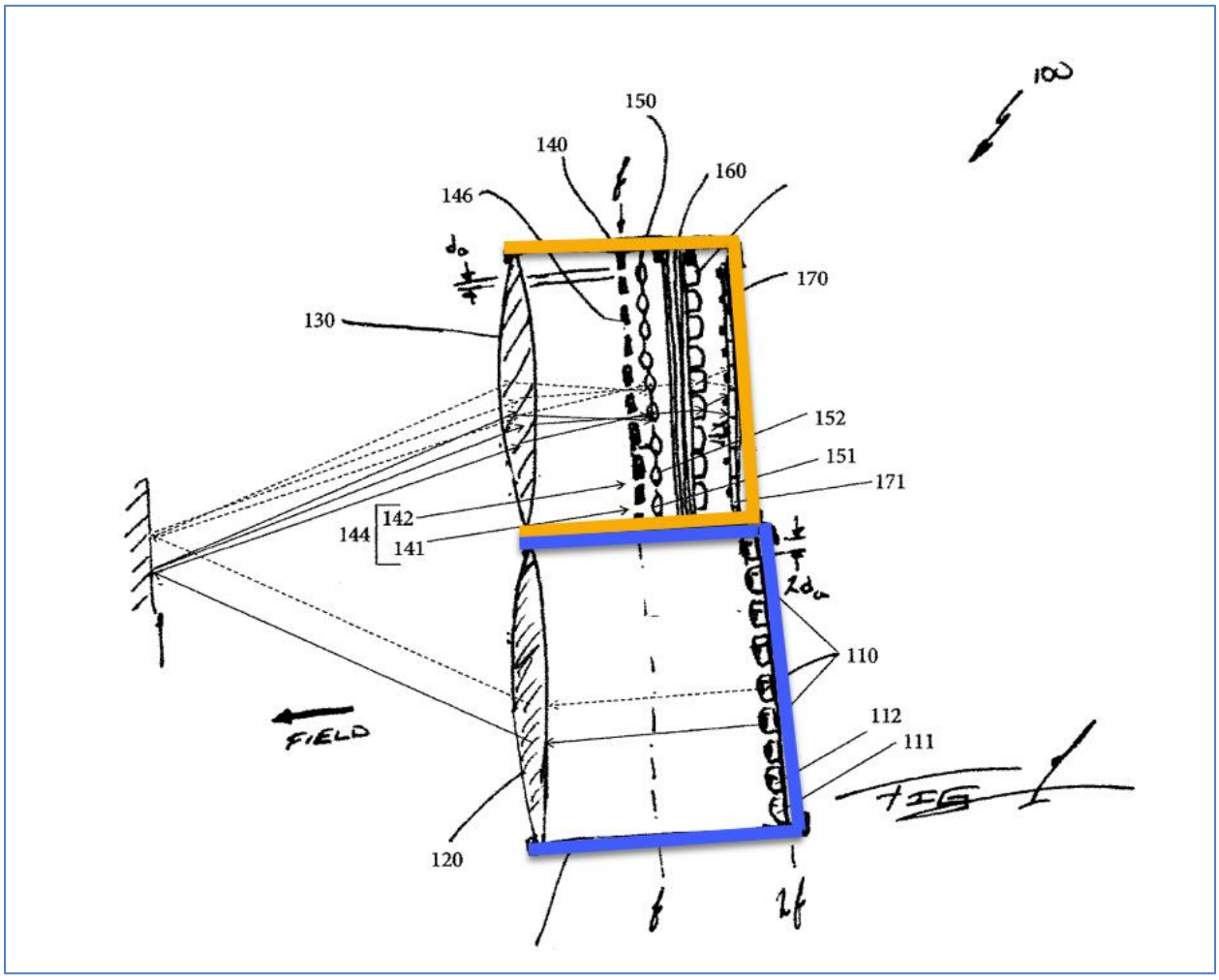
372. The Johnson-Pardhan-Zhang-Pacala-2017 combination discloses claim 4 for the reasons I discussed in my analysis of Ground 1, Claim 4.

4. Claim 5: The light ranging system of claim 4 wherein the light ranging device is mounted within a ranging device housing disposed within the enclosure between the fourth circuit board and the enclosure top with the transmit module mounted to a first portion of the ranging device housing and the receive module mounted to a second

portion of the ranging device housing directly adjacent to the first portion

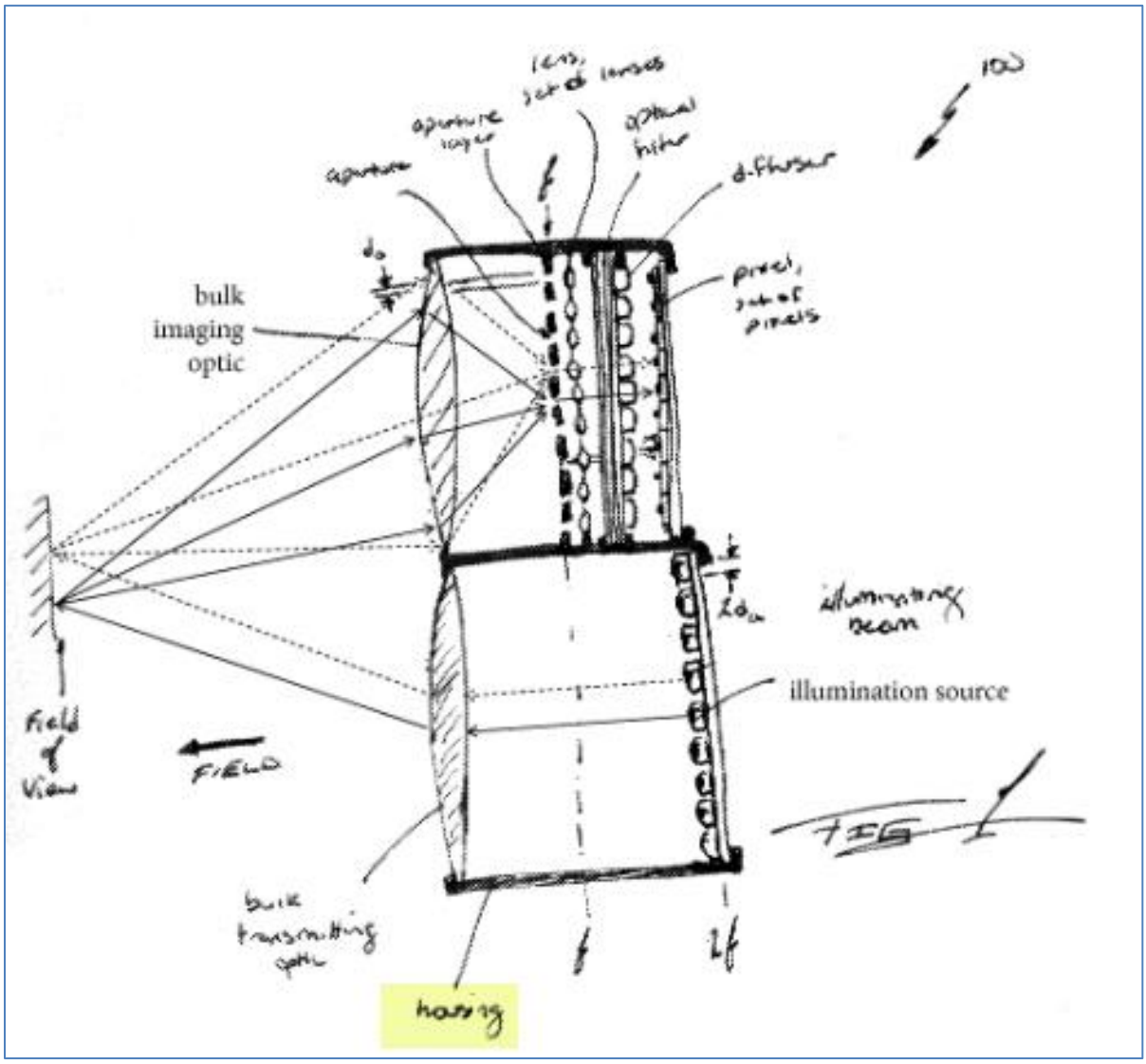
373. I showed in my analysis of Ground 1 that the additional limitation of Claim 5 is disclosed by Pacala. Pacala-2017 also discloses this limitation. Thus, in my opinion the additional limitation of claim 5 is also obvious in further view of Pacala-2017.

374. Pacala-2017 discloses that the light ranging device is mounted within a ranging device housing disposed within the enclosure, and that the transmit module is mounted to a first portion (blue) and the receive module is mounted to a second portion (orange) of the ranging device housing that are directly adjacent to one another:



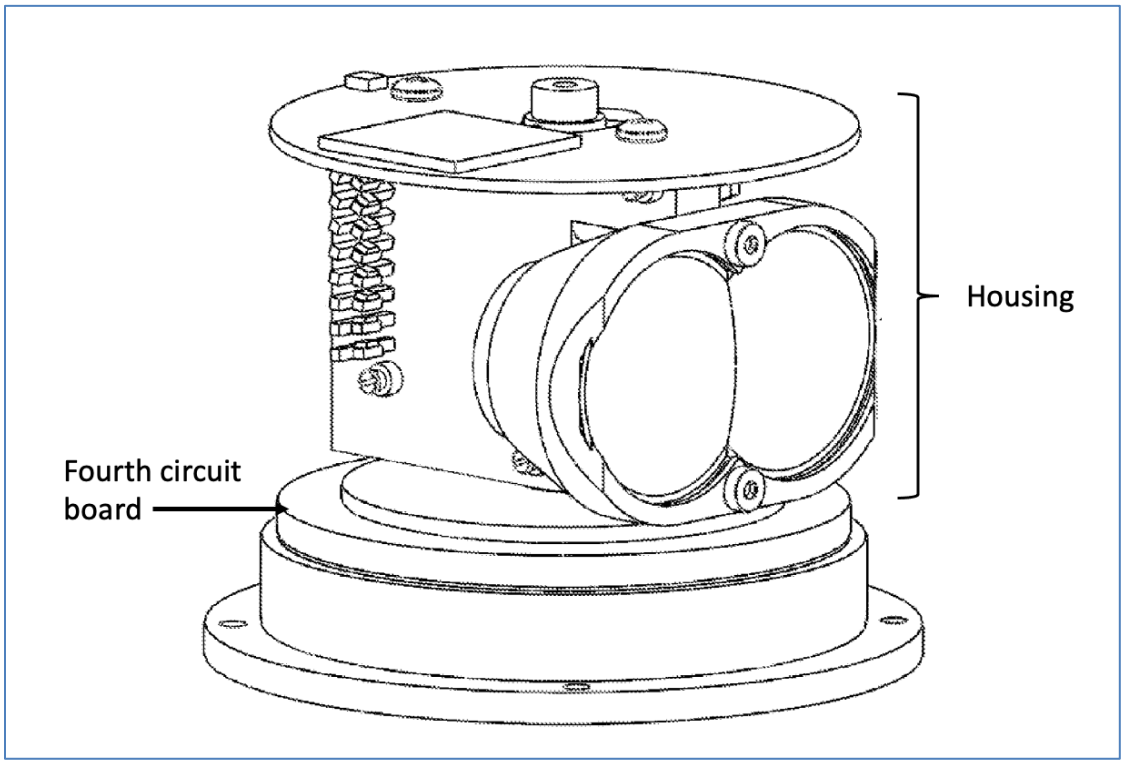
EX1013, Fig. 1.

375. The Pacala-2017 Provisional Application, reproduced below, labels the "housing" with text (highlighted):



EX1046, 11.

376. And as I explained in connection with my analysis of claim 5 in Ground 1, in view of Johnson's teachings, the fourth circuit board would be part of the rotating turret 60 of Pacala, such that the LiDAR housing is disposed between the top of the enclosure and the fourth circuit board as illustrated below:

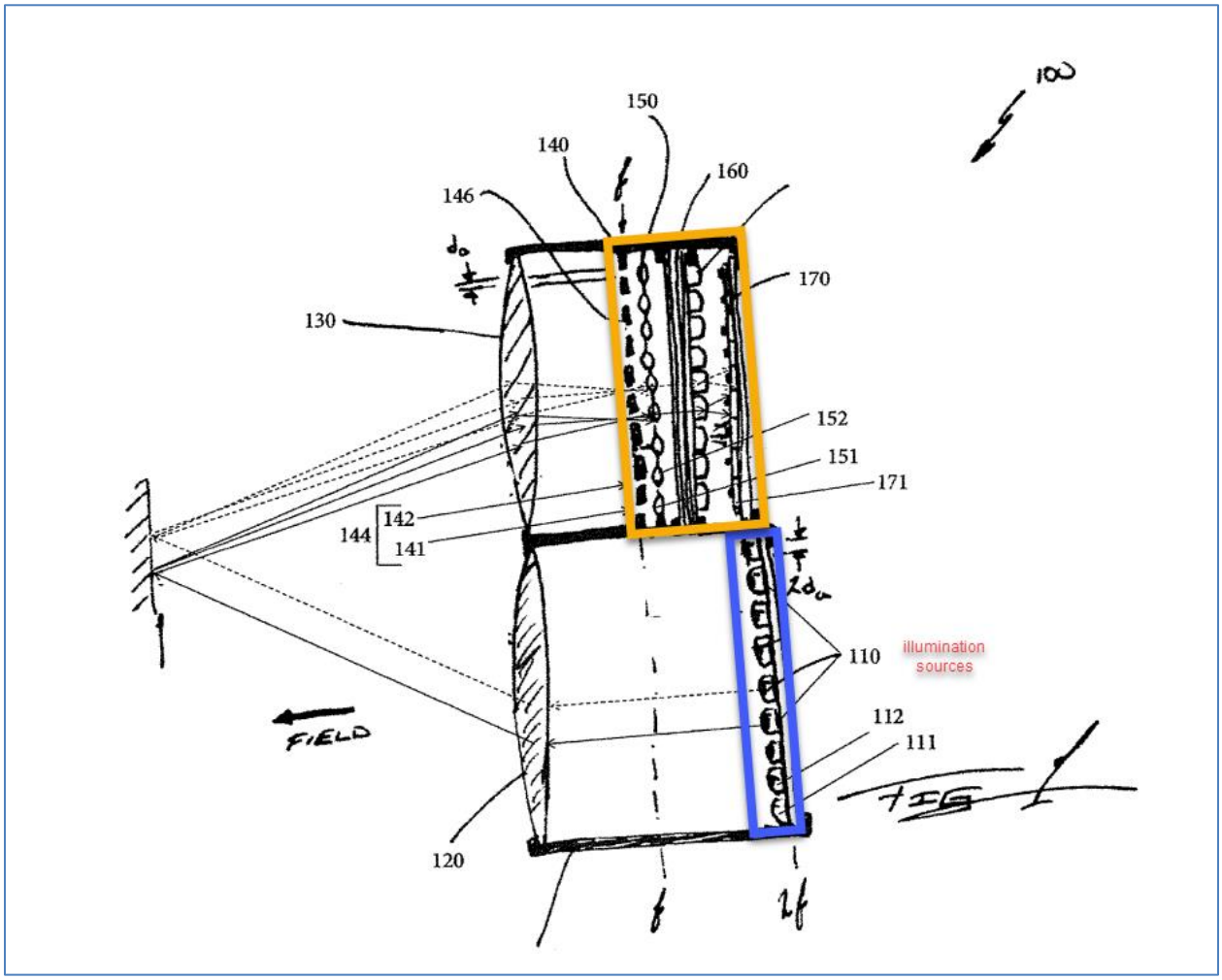


EX1004, Fig. 2.

5. Claim 6: The light ranging system of claim 5 wherein transmit module comprises a fifth circuit board with supporting circuitry for the illumination source and the receive module comprises a sixth circuit board with supporting circuitry for the detector circuitry, and wherein the fifth circuit board is mounted to the first housing portion of the ranging device housing and aligned parallel to the axis of rotation and the sixth circuit board is mounted to the second housing portion of the ranging device housing and aligned parallel to the axis of rotation

377. I showed in my analysis of Ground 1 that the additional limitation of Claim 6 is disclosed by Pacala. Pacala-2017 also discloses this limitation. Thus, in my opinion the additional limitation of claim 6 is also obvious in further view of Pacala-2017.

378. For example, Figure 1 of Pacala-2017 illustrates the "transmit module" comprising "a fifth circuit board with supporting circuitry for the illumination sources" (blue) and the "receive module" comprising "a sixth circuit board with supporting circuitry for the detector circuitry" (orange):



EX1013, [0016]-[0018], [0056], Fig. 1. Figure 1 also shows each of these circuit boards mounted to a housing portion of the LiDAR device (the housing structures that are located on each side of the circuit boards).

379. Pacala-2017 also explains that the light ranging device is "rotated about

an axis" that is "parallel" the "column of apertures." *Id*., [0016]. A POSITA would have understood that to rotate the light ranging device about an axis that is "parallel" to the column of apertures, the transmit and receive modules would be mounted to a first and second housing portion that is "parallel to the axis of rotation."

6. (Claims 7) The light ranging system of claim 1 wherein the annular arrangement comprises a plurality of separate permanent magnets / (Claim 16) The light ranging system of claim 14 wherein the plurality of magnetic poles rotor in the annular arrangement of the rotor assembly comprise a plurality of separate permanent magnets

380. The Johnson-Pardhan-Zhang-Pacala-2017 combination discloses the limitation of claims 7 and 16 for the reasons I discussed in my analysis of Ground 1, Claim 7/16.

7. (Claim 8) The light ranging system of claim 1 further comprising circuitry to compute ranging data based on the reflected portion of the electromagnetic radiation pulses / (Claim 19) The light ranging system of claim 14 wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the illumination source and the detection of reflected portions of the electromagnetic radiation pulses by the receive circuitry

381. Pacala-2017 discloses that the additional limitations recited in these claims are a basic function of a light ranging device: "Based on the time elapsed between emission of the pulse of light and detection of the returned pulse of light, a distance is estimated." EX1013, 1:21-33; *see also* EX1015, 1:14-22; Section VI.A.

8. Claim 9: The light ranging system of claim 1 wherein the stator driver circuit is configured to rotate the rotor assembly at a rate between 10 to 30 Hz

382. The Johnson-Pardhan-Zhang-Pacala-2017 combination discloses the limitation of claim 9 for the reasons I discussed in my analysis of Ground 1, Claim 9.

9. Claim 11: The light ranging system of claim 1 wherein a number of stator elements in the plurality of stator elements is a multiple of three and the stator driver circuit is configured to provide a 3-phase alternating signal to the plurality of stator elements.

383. The Johnson-Pardhan-Zhang-Pacala-2017 combination discloses the limitation of claim 11 for the reasons I discussed in my analysis of Ground 1, Claim 11.

10. (Claim 12) The light ranging system of claim 1 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the illumination pattern is coincident with the field of view of one pixel in the plurality of pixels / (Claim 20) The light ranging system of claim 14 wherein the detector circuitry comprises a plurality of pixels with each pixel in the plurality of pixels having a field of view that is non-overlapping with the fields of view of all other pixels in the plurality of pixels, and wherein the illumination source is configured to project discrete beams of electromagnetic radiation into the surrounding environment according to an illumination pattern where each discrete beam in the

illumination pattern is coincident with the field of view of one pixel in the plurality of pixels

384. I showed in my analysis of Ground 4 that the additional limitations of Claims 12 and 20 are disclosed by Spector. Pacala-2017 also discloses this limitation. Thus, in my opinion these limitations are also obvious in further view of Pacala-2017, rather than Spector.

385. Pacala-2017 discloses that its detector circuitry comprises a plurality of pixels. For instance, Pacala-2017 states that each pixel "in the set of pixels 170 includes an array of single-photon avalanche diode detectors (hereinafter 'SPADs')." EX1013, [0037]-[0043], Fig. 3, Claims 6-7, 9.

386. Pacala-2017 also discloses that each pixel in the plurality of pixels has a field-of-view that is non-overlapping with the fields-of-view of all other pixels in the plurality of pixels. For instance, Figures 2-3 show "a column of offset apertures arranged behind a bulk imaging optic 130" that "defin[e] discrete fields of view in a field ahead of the bulk imaging optic 130 (that is non-overlapping fields of view beyond a threshold distance from the system)." *Id.*, [0016], [0024]; Claims 1, 6-7.

387. Further, the illumination sources (*e.g.*, 111-112) project discrete beams of light into the surrounding environment according to an illumination pattern that are each coincident with the field-of-view of one of the pixels. *Id.*, [0027] ("illumination source 111 projects an illuminating beam that is substantially

coincident (and substantially the same size as or minimally larger than) the field-of-view defined by the first aperture 141"), [0023], [0025], [0044], [0056], Figs. 1-4.

11. (Claim 13) The light ranging system of claim 12 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs) / (Claim 21) The light ranging system of claim 20 wherein each pixel in the plurality of pixels comprises a plurality of single photon avalanche diodes (SPADs)

388. I showed in my analysis of Ground 5 that the additional limitations of Claims 13 and 21 are disclosed by Droz. Pacala-2017 also discloses these limitations. Thus, in my opinion these limitations are also obvious in view of Pacala-2017, rather than Droz.

389. Pacala-2017 also expressly states that each pixel in the plurality of pixels comprises a plurality of SPADs: "each pixel can include a single row 16 SPADs." EX1013, [0039]-[0043], Fig. 3, Claim 9. A POSITA would have found it obvious to integrate a plurality of SPADs into the pixels of Pacala.

12. Claim 17: The light ranging system of claim 14 further comprising a wireless power transformer integrated directly onto the stator and rotor circuit boards, the wireless power transformer comprising a first annular transformer coil disposed on a surface of the stator circuit board and a second annular transformer coil disposed on a surface of the rotor circuit board in an opposing relationship with the first annular transformer coil, wherein the first transformer coil is concentric with and positioned outside an outer perimeter of the plurality of stator elements and the second transformer coil is concentric with

and positioned outside an outer perimeter of the rotor assembly annular arrangement

390. The Johnson-Pardhan-Zhang-Pacala-2017 combination discloses the limitation of claim 17 for the reasons I discussed in my analysis of Ground 1, Claim 17.

13. Motivation to Combine

391. A POSITA would have been motivated to combine Johnson-Pardhan-Zhang for the reasons discussed in Ground 1. A POSITA would be motivated to further combine Pacala-2017 for at least the reason I discuss below.

392. ***First***, the references provide an express motivation to integrate the Pacala-2017 LiDAR sensor into the rotor-stator structure of Pacala-Johnson-Pardhan-Zhang. For instance, Pacala-2017 discloses a LiDAR device that can be "rotated about an axis" (EX1013, [0016]), but does not disclose the details of the rotation structures. Similarly, Pacala-Johnson-Pardhan-Zhang teach that the "LIDAR unit [] may be any sensor." EX1005, 7:23-26; EX1006, 13:46-51. Thus, a POSITA would have been motivated to integrate a LiDAR sensor such as Pacala-2017 on the surface of the rotational structure. *See Wavetronix*, 746 Fed. Appx 984 at 991. A POSITA would have been particularly motivated to apply Pacala-2017 because it teaches a LiDAR sensor that can "reduc[e] noise in the system and increase SNR." EX1013, [0033]. Thus, a POSITA would have been motivated to incorporate the LiDAR device of Pacala-2017 to reduce crosstalk and multipath

signals in the system.

393. ***Second***, a POSITA would have been motivated to combine Pacala-2017, Johnson, Pardhan, and Zhang as described above because the combination merely combines prior art elements according to known methods for the reasons I discussed in connection with Ground 1.

14. Reasonable Expectation of Success

394. In my opinion, a POSITA also would have had a reasonable expectation of success in combining the teachings of the prior art references in the manner I discussed above.

395. ***First***, rotational LiDAR devices had been widely studied and used before the priority date, and the state of the art thus confirms that a POSITA would have had a reasonable expectation of success combining the teachings of Pacala-2017 with Johnson, Pardhan and Zhang.

396. ***Second***, a POSITA would have understood that Pacala-2017's LiDAR sensor could be integrated within the rotor-stator structure of Johnson-Pardhan-Zhang using basic electrical engineering design principles.

I. Ground 9: Johnson, Pardhan, Zhang, Cai, and Yan in further view of Pacala-2017 renders claims 22-25 obvious.

397. In my analysis of Ground 6, I rely upon Pacala for the overall structure of a light ranging system—namely, disclosure of the claimed enclosure (Limitation 22(b)) and the claimed light ranging device within the enclosure with transmit and

receive modules (Limitations 22(f.i) and 22(f.iii)). Similarly, for Ground 7 I rely upon Spector for the additional limitation of claim 25.

398. This ground replaces the Pacala-Spector combination with Pacala-2017. Thus, Johnson-Pardhan-Zhang-Cai-Yan are combined in the same way as discussed in Ground 6. The combined system is then further modified by integrating the LiDAR device of Pacala-2017, rather than that of Pacala-Spector.

1. Claims 22-24

(a) Limitation 22(b): an enclosure having a base, a top cover and an optically transparent window disposed between the base and the top cover and extending fully around a periphery of the enclosure

399. Pardhan discloses this limitation, as I showed in connection with Ground 8, Limitation 1(b)/14(b).

(b) Limitation 22(f.i): a light ranging device coupled to rotate with the rotor circuit board within the enclosure, the light ranging device comprising a transmit module and a receive module, the transmit module comprising a bulk transmitting optic and a light source operable to transmit pulses of electromagnetic radiation through the bulk transmitting optic and through the window to objects in a surrounding environment, the receive module comprising a bulk receiver optic and detector circuitry operable to detect reflected portions of the electromagnetic radiation pulses received through the window that are reflected from the objects in the surrounding environment

400. Pacala-2017 discloses Limitation 22(f.i), as I showed in connection

with Ground 8, Claim 1(i)/14(j).

(c) Limitation 22(f.iii): wherein the light ranging device determines distances to objects in the surrounding environment based on elapsed times between the pulses of electromagnetic radiation emitted from the light source and the detection of reflected portions of the electromagnetic radiation pulses by the detector circuitry

401. Pacala-2017 discloses Limitation 22(f.iii), as I showed in connection with Ground 8, Claims 8/19.

(d) Remaining Limitations

402. The remaining limitations correspond to limitations discussed in Ground 8. In my opinion, the Johnson-Pardhan-Zhang-Cai-Yan-Pacala-2017 combination discloses these limitations for the same reasons discussed in Ground 8.

2. Claim 25: The light ranging system of claim 22 wherein the light source comprises a plurality of emitters configured to project a plurality of illuminating beams in a field ahead of the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of pixels

403. The Johnson-Pardhan-Zhang-Cai-Yan-Pacala-2017 combination also discloses the additional limitation of claim 25.

404. For example, Claim 25 recites that "the light source comprises a plurality of emitters configured to project a plurality of illuminating beams in a field ahead of the optical system according to an illumination pattern that substantially

matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of pixels." Pacala-2017 discloses that the emitters of the LiDAR device "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*., [0016], [0045]-[0046], Fig. 2. The field-of-view of the apertures are non-overlapping and correspond to the field-of-view of the plurality of pixels. Thus, applying the teaching of Pacala-2017 to Pacala renders obvious claim 25.

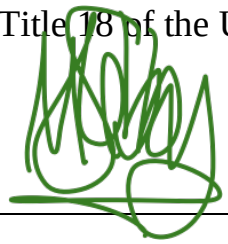
405. A POSITA would have been motivated to combine Johnson-Pardhan-Zhang-Cai-Yan for the reasons discussed in Ground 6. A POSITA would have been further motivated to combine the teachings of Pacala-2017 for the reasons I discussed in connection with Ground 8. September

X. CONCLUSION

134. I understand that this declaration will be filed as evidence in a contested case before the PTAB. I acknowledge that I may be subject to cross-examination in the case and that cross-examination will take place in the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

135. I declare that all statements made in this declaration of my own

knowledge are true to the best of my knowledge and that all statements made on information and belief are believed to be true. These statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: September 13, 2023 By: 

Michael Lebby, Ph.D.

Appendix A

Michael Lebby

EDUCATION:

2004, Doctor of Engineering (D. Eng.)
University of Bradford, United Kingdom
Citation, "*Technical Contributions to Optoelectronics"*
(NB: This is a higher doctorate awarded on technical contribution to the field)

1987, Ph.D.
University of Bradford, United Kingdom
Thesis, "*Characterization and Fabrication of the HFET and BICFET"*

1985, MBA
University of Bradford, United Kingdom
Thesis, "*Small Business Planning for a Start-up"*

1984, Bachelors (B. Eng. – Honours)
University of Bradford, United Kingdom
Thesis, "*Computer Aided Testing of Semiconductor Devices"*

SUMMARY OF TECHNICAL EXPERTISE:

Industry roles (majority of career): Dr, Lebby has founded and led several companies in various positions including CEO and CTO (Ignis Optics, Oculi, One Chip Photonics, OIDA, Translucent Photonics, and Lightwave Logic). Dr. Lebby is currently Chairman & CEO of a public company (Lightwave Logic Inc. NASDAQ:LWLG). As CEO, Dr. Lebby led LWLG from an OTCQB company to OTCQX, and then to up-list on NASDAQ, organically, without raising financing (which is extremely rare), on 1st September 2021. Subsequently, Dr. Lebby was invited to 'ring the bell' and close the NASDAQ stock market for ethe week on 10th September 2021. The event was carried live on Fox, CNBC, Bloomberg, and BNN networks. On 1st September 2022, Lebby was elected Chairman of Lightwave Logic Inc.

Academia role (minor part of career): Dr. Lebby has been a full professor (part-time) in optoelectronics at Glyndŵr University, Wales, UK (2013-15). Dr. Lebby has over 60 publications and has a google scholar h-index = 46 (which includes issued patents and published patent applications), i10-index = 165, with over 8400 citations.

Key professional bodies: Dr. Lebby is a Fellow of the National Academy of Inventors (NAI), the IEEE (Institute of Electrical and Electronic Engineers), and the OSA (Optical Society of America). Dr. Lebby is a Chartered Engineer of the British Institute of Electrical Engineers (roughly equivalent to the professional engineer status in USA).

Dr. Lebby started work in telecommunications industry and has generated over 40 years of experience in a number of technical disciplines and technologies. Dr. Lebby is well versed in electronics, semiconductor physics, optoelectronics, optics, materials, packaging, module design, ICs and electrical engineering in general. Dr. Lebby has experience in commercial and industrial research of technologies such as silicon, compound semiconductors, manufacturing, fabrication, design, simulation, testing, evaluation, reliability, qualification of new ideas, concepts and products.

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
1 Hawthorne St., unit 25a, San Francisco, CA 94105, USA; mobile +1 717 839 7078; drmlebby@gmail.com

Dr. Lebby is co-inventor of the world's first 'oxide VCSEL' (this is a type of semiconductor laser) that is now being utilized for consumer applications (*Face ID of Apple's iPhone as an example, laser mice for PCs as another example*). US Patent #5359618 "High Efficiency VCSEL and Method of Fabrication" issued 25th October 1994. Estimated commercial volumes of this semiconductor device exceed many billions of units.

Dr. Lebby has over 230 issued utility patents with the USPTO in subjects such as electronics, optoelectronics, photonics, packaging, transceiver modules, optical sub-assemblies, materials, epitaxial growth, device design, assembly, and various active and passive components (both electronic and optoelectronic). Dr. Lebby regularly receives invites to speak at technical conferences as well as banking and financial conferences. Dr. Lebby has appeared in panels and interviews many times and regularly is communicating with the public on various platforms. Dr. Lebby is currently chairman of the International PIC conference based in Europe (since it's conception in 2015). Dr. Lebby is inventor or co-inventor of ~230 issued USPTO utility patents (or over 450 if international derivatives are included), as well as over 80 published patent applications.

Dr. Lebby has participated in over 150 patent litigation cases as a technical expert witness, including over 20 trials and over 60 depositions. Dr. Lebby has authored numerous expert reports and is familiar with State (District), Federal (ITC) and PTAB-IPR court processes for expert witness testimony. Dr. Lebby has been cited in patent litigation case history (ITC investigation in the matter of: Certain Active Optical Cables and Products Containing the Same (ITC Inv #337-TA-1233)). See details below in Expert Witness Experience.

The types of products that Dr. Lebby understands and includes but are not limited to; Light Emitting Diodes (LEDs), Laser Diodes (LDs), photodetectors (PDs), optical waveguides, fiber optics, displays (LCD, LED, OLED), lighting luminaires, plastic photonics, optical polymers, sensors, LIDAR, solar cells, lighting, data communication, CMOS, and even new opportunities such as medical and life science applications for photonics. Dr. Lebby is internationally known for his work with integrated photonics, PICs (Photonic Integrated Circuits), silicon photonics, and semiconductor technologies such as InP, GaAs, III-GaN, silicon, as well as SiGe and silicon ICs (MOSFETs, FinFETs, bipolar), power FETs, RF FETs, various display technologies such as LCD, OLED, LED, cameras, as well as micro-fluidics and nanostructures/wires etc. Dr. Lebby has worked with DC current as well as AC current, high frequency design, microwave design, and multi-wavelength, visible wavelengths, in addition to 850nm/1310nm/1500nm/NIR fiber optic communications. Dr. Lebby has worked extensively in fiber optics which includes Fiber based systems, chassis', trays, modules, adapters, splice devices, connectors, transceivers, packaging as well as architecture and optical communication standards/protocols.

Dr. Lebby is currently CEO of a public company (Lightwave Logic Inc. NASDAQ:LWLG). As CEO, Dr. Lebby took LWLG from an OTCQX company to up-list on NASDAQ, organically, without raising financing (which is extremely rare). LWLG was listed on NASDAQ 1st September 2021, and Dr. Lebby was invited to close the NASDAQ stock market on 10th September 2021 and "ring the bell". The event was carried on Fox, CNBC, Bloomberg, and BNN networks.

Starting in January 2024, Dr. Lebby has been voted to become chairman of Optica's Corporate Engagement Council and become a member of the Optica Board of Directors. Dr. Lebby is currently a member of Optica's Corporate Engagement Council which represents the global photonics industry.

BIOGRAPHY:

Biography: Michael S. Lebby joined Lightwave Logic as a member of the Board of Directors in 2015. In May 2017, Dr. Lebby assumed the role of CEO, and in September 2022, Chairman and CEO of Lightwave Logic Inc (NASDAQ:LWLG). Lightwave Logic is a technological company commercializing Electro-Optical polymers and successfully up listed the company to NASDAQ on 1st September, 2021. Dr. Lebby was invited to close the NASDAQ stock market on 10th September 2021. The event was carried on Fox, CNBC, Bloomberg, BNN networks.

Dr. Lebby (born 1961, London, UK) is an Anglo-American entrepreneur and intrapreneur in the fields of optoelectronics/photonics electronics and semiconductors. Dr. Lebby's career started with the British Government in 1977 in telecommunications and he did research at their research labs (RSRE Malvern) in the early 1980s. Dr. Lebby worked at AT&T's research labs: Bell Labs (1985-1989) in photonics, and subsequently drove the development (and co-authored the first patent) of the oxide VCSEL diode laser at Motorola in the 1990s (which is now used in laser mice, 3D structured light sensing/FaceID in mobile phones, optical interconnects; where volumes of the laser are over 1B units today). From 2005-2010 he led the USA trade association in optoelectronics (OIDA) and represented the optoelectronics and photonics industry on Capitol Hill.

Dr. Lebby has led and run technical start-ups and commercialized optoelectronic and photonics technology into volume manufacturing. Dr. Lebby has also had roles as a Venture Capitalist specializing in Optical

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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Communications. He is currently a technical expert to the European Commission. He is a Fellow member of NAI (National Academy of Inventors), IEEE, and OSA, and has been voted PIC (Photonic Integrated Circuit) business leader of the year by the PIC International Conference in 2018.

Dr. Lebby holds over 450 issued international patents (as per search engine) in photonics and electronics, that have been derived from over 230 issued USPTO utility patents, mostly in the field of optoelectronics, photonics, and semiconductors. He has been cited by the USPTO to be in the most prolific 75 inventors in USA from 1988-1997.

Dr. Lebby is passionate about photonics and has focused his efforts over the last 30years to drive new photonics manufacturing programs in USA and Europe as well as industry-based photonics technology roadmaps.

Dr. Lebby is also passionate about optics and philately, and has been elected to both the London Guild of Spectacle Makers as well as the Royal Philatelic Society London.

WORK HISTORY:

2003 – Present **GenusTechnik Inc.,** *CEO and CTO (part-time consulting)*

GenusTechnik Inc. (previously Oculi LLC), provides consulting in expert witness, trial, deposition, expert reports, infringement, invalidity, and various patent and IP litigation in photonics, optoelectronics, semiconductors, and fiber optic telecommunication technology segments. Engaged patent agencies have included: IMS Expert Services, Thomson Reuters Expert Witness Services (now Round Table Group), LitXpert Expert Witness Group, Teklicon Expert Witness Agency, Beche Expert Services Group, Forensis Group: Expert Witness Services, and Expertconnect. GenusTechnik Inc. also provides consulting to Ambature Inc. in superconductivity.

2015 – Present **Lightwave Logic (NASDAQ:LWLG)**, *Chairman, CEO, & Director, Board of Directors*

In 2015 Dr. Lebby became a director of Lightwave Logic to assist in the company for competitive optical modulator products and associated packaging, manufacturing, and technology roadmaps/marketing. In May 2017, Dr. Lebby became CEO of Lightwave Logic. On 1st September 2021, Dr. Lebby successfully guided Lightwave Logic to up-list to NASDAQ, and was invited to ring the closing bell on 10th September 2021. The NASDAQ up-list was organic i.e. no reverse split, no raised funds. The organic up-list is considered very rare in the financial industry. In September 2022, Lebby became Chairman and CEO of Lightwave Logic Inc.

2014 – 2016 **University Southern California,** *Director CFR (Corp & Foundation Relations)*

Dr. Lebby assisted USC Viterbi Engineering to foster tighter faculty-industry relationships in high technology, IT, social media, graphic arts, electronics, photonics (solar, display, medical) and fiber communications segments.

2013 – Present **European Commission**, *Technical Expert*

In 2013 Dr. Lebby became a technical expert for the Photonics Unit of the European Commission. Dr. Lebby has participated in organizing workshops, lectures, evaluating photonics proposals, and advising the Commission on funded projects. Dr. Lebby currently is an advisor on 7 photonics pilot lines (MIRPHAB, PI-SCALE, PIX4LIFE, PIXAPP, InPULSE, Phabulous, PhotonHub) and photonics based cardiovascular disease programs (CARDIS and InSide). More recently, Dr. Lebby has been consulting on larger framework (multi-country) projects that include electronics (power/RF) as well as photonic based technologies. Work includes displays, LEDs, lighting/LED luminaires, OLEDs, micro-optics, InP/Silicon photonics, near infra-red technologies, fiber optics, sensing, medical photonics, and medical imaging, technology roadmapping, electronics, IC design etc.

2013 – 2015 **OneChip Photonics Corporation**, *President and CEO*

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In 2008 Dr. Lebby was elected independent board member for One Chip Photonics Inc. He was elected CEO in 2013. One Chip Photonics focused on technical and business operational strategy for communications based InP Photonic Integrated Circuit (PIC) and optoelectronic Integrated Circuit (OEIC) platforms.

2013 – 2015 **Glyndŵr University**, *Professor, Chair of Optoelectronics*

In 2013 Dr. Lebby became full Professor of Optoelectronics (part-time) to assist Glyndwr University to position itself as a leader in optoelectronics and photonics. Areas of focus include design, simulation, and testing of photonic integrated circuits (PICs) and optoelectronics integrated circuits (OEICs), laser diodes, displays, optics, and solar cells.

2010 – 2013 **Translucent, Inc.,** *GM and CTO*

Dr. Lebby positioned Translucent on the product development and manufacture of epitaxial semiconductor wafers for the solar, power and lighting industries. Dr. Lebby led the R&D and development of MBE based rare earth oxide single crystal epitaxial layers deposited onto large silicon wafers. On top of these wafers both MBE and MOCVD Gallium Nitride epitaxial device layers were grown for devices. The use of GaN-on-Si is expected to be a strong catalyst for change in the power electronics and LED lighting industries. In a parallel program at Translucent, Dr. Lebby led the development efforts to develop and productize Germanium-Tin (GeSn) template wafers onto large format silicon wafers (Ge-on-Si) to enable cost effective, and ultra-high efficiency multi-junction solar cells for the CPV industry. Areas of advanced interconnect using new and novel material compounds were explored.

2005 – 2010 **OIDA** (Optoelectronic Industry Development Association)**,** *Executive Director, President, and CEO (Board Member)*

Dr. Lebby represented the optoelectronics industry and organized technical conferences/workshops/forecasts with industry roadmaps. Initiated green photonics metrics. Dr. Lebby positioned OIDA as a national resource in the field of optoelectronics and has represented industry in many capacities ranging from talks, papers, expert witness, testimony, market and technical reports. Dr. Lebby created ***new industry-based initiatives*** in fiber optics broadband as well as the green photonics movement (solar technologies, displays, LED lighting technologies) that is now occurring globally.

2003 – 2005 **OCLARO (after acquisition by Bookham in 2003),** *VP Technology and Business Development*

Telecommunication optoelectronic components, San Jose, Ca. Focus on technology strategy for components and sub-systems.

2001–- 2003 **Ignis Optics,** *President and CEO (Founder/Board Member)*

Venture-backed start-up, San Jose, California manufacturing 10Gbps and OC192/OC48 fiber optic transceivers with micro-controllers using the XFP form-factor.

1999 – 2001 **Intel Capital,** *Director Business Development/Investor (w/Board observer positions on Investment)*

Intel Capital, Santa Clara, California. In 1999, Dr. Lebby joined Intel as a corporate investor and was responsible for sourcing, negotiating, and closing private placement equity deals in the optical networking, component, display, projection technologies, LED lighting, LED luminaires, and semiconductor arenas.

1998 – 1999 **TE Connectivity (renamed from AMP, then Tyco Electronics),** *Director Technology & Business Development (Fiber Optics)*

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Global Optoelectronics Division: Technology strategy for optical communications products.

1989 – 1998 **Motorola,** *R&D Manager*

Corporate R&D Labs, Tempe, Arizona. Optoelectronics: VCSEL based product solutions (OPTOBUS); materials, devices, packaging, systems. Other technologies included displays, field emission, LED, LCD, OLED, virtual/micro and projection. At the time, Dr. Lebby was also the lead inventor in Motorola's history with over 150 issued utility patents. Dr. Lebby worked in the silicon and compound semiconductor fabrication plants (fabs) to become proficient in deposition/etching/alignment tooling as well as design and simulation.

1985 – 1989 **AT&T,** *Researcher*

AT&T Bell Labs - Photonics Research Dept (Dept 11366), Holmdel, NJ. Dr. Lebby designed and fabricated new GaAs and InP optoelectronic and electronic devices that were grown both by MOCVD and MBE for projects that included optical computing and fiber optic communications.

1977 – 1984 **UK Ministry of Defense,** *Apprenticeship/Journeyman + Electronics Engineer (REME – Royal Electrical and Mechanical Engineers, and RSRE – Royal Signals and Radar Establishment)*

Dr. Lebby started his career at the Royal Electrical and Mechanical Engineer (REME) division of the Ministry of Defence in the UK. Lebby was a telecommunications apprentice, and repaired all types of radio/RF communications equipment. Lebby qualified as a fully qualified Journeyman or Apprentice specializing in telecommunications in 1980. Dr. Lebby moved to the Royal Signal and Radar Establishment (RSRE) to study material and characterization issues of GaAs and InP devices.

SELECTED PROFESSIONAL ACTIVITIES & AWARDS:

- Elected Chairman of Lightwave Logic Inc., NASDAQ:LWLG 1st September 2022
- Elected to the Corporate Engagement Council (newly formed OIDA to represent the global optical industry) for Optica in June 2022 and voted to become Chairman in 2024 that is represented on Optica's Board of Directors.
- Invited to ring the closing bell of NASDAQ (with associated TV interviews) on 10th September, 2021
- Elected Fellow of the **National Academy of Inventors** (NAI) in 2020.
- Voted winner at the PIC Conference (Photonic Integrated Circuits) as PIC **Entrepreneur and Business Leader of the Year** (March 2018).
- Dr. Lebby is **co-inventor of the oxide VCSEL** (semiconductor laser) that is now being utilized for consumer applications (*Face ID of Apple's iPhone as an example*). US Patent #5359618 "High Efficiency VCSEL and Method of Fabrication" issued 25th October 1994.
- Dr. Lebby was recognized professionally as a **Fellow of IEEE (2005) and OSA (2007)** with his technical contributions to the field of optoelectronics.
- Dr. Lebby is a member of the Fellows review committee of IEEE.
- As an inventor Dr. Lebby has achieved **>230 issued utility patents with the USPTO.**
- As an inventor Dr. Lebby has ~80 published utility patent applications with the USPTO
- As an inventor Dr. Lebby has over 450 issued patents world-wide if international derivatives are counted.
- Dr. Lebby's novel laser-based device, packaging, modules designs led Motorola to sell their patent portfolio independently where a number of the patents have "very high licensing coefficients." Dr. Lebby was given a special award from the Chairman of Motorola for exemplary patent invention accomplishments in 1998 and **# 1 prolific inventor in Motorola's history**.
- **Over 60 publications** (www.linkedin.com/in/lebby)
- **Over 300 public media activities** (that include: Books, Chapters, Reports, Abstracts, Videos, Lectures, Speeches, Reviews, Courses, Talks, Invited Talks, Keynote Talks, Plenary Talks, Webinars, Interviews, Articles, etc.). See at www.linkedin.com/in/lebby

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- Author of OIDA's **annual market optoelectronics report** and forecast (2009 version is over 600 pages), which receives international exposure and recognition. Regularly interacts with government agencies in Washington DC on photonics-based projects (DARPA, ARPA-E, NIH, NSF, DOE, NIST, DoD etc.). Typical chapters included: LEDs, laser diodes, fiber optic communications, sensors, displays, solar, green photonics, military photonics, and applications of photonics such as solid-state lighting (LED luminaires), automotive, medical, etc.
- Is the recipient of a **2nd doctorate** (higher) from Bradford University, UK, and only the second in the universities history to receive a D.Eng from industry (rest being academia).
- **Intrepreneur** at: (i) Motorola: Co-founded Optobus division – VCSEL laser based parallel optical interconnect solution, and (ii) Intel: Co-founded the Intel optics division for silicon photonics where over $300M was initially invested for the division.
- **Entrepreneur**: Founded (and CEO) Ignis Optics Inc., a venture backed company (>$30M) that designed and manufactured 10Gbps fiber optic transceivers. Sold the company to Bookham (NASDAQ: BKHM) in 2003. Restructured OneChip Photonics (as CEO) through bankruptcy, and new VC-based funding. Assisted in the raising of >$50M VC funding as a member of BoD. Founded Oculi LLC and Obsidian Motors LLC.
- IEEE CPMT **Board of Governors** ('98- '02); IEEE Phoenix Waves and Devices Junior Engineer of the Year (1993); CPMT Distinguished lecturer (2000), CPMT technical committee (TC-10 & ECTC) 1991 to 2011
- Advised at **Board of Director** level for a number of technical start-ups
- **Chartered Engineer** (C.Eng) from IEE (UK). The chartered engineering status is equivalent to the US PE (professional engineer)

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EXPERT WITNESS EXPERIENCE

Summary:
Depositions (total-to-date) >50
Trial/Hearing/Court appearances >20 (with IPR/PTAB 'paper trial', this total increases to >25)

Cited patent litigation case history: In essence, the following case history means that the expert doesn't have to disclose every minute detail in his expert report. He is allowed to disclose theories in the report and expand on them in his witness statement.

See also In The Matter Of Certain Light-Emitting Diode Products, Systems, And Components Thereof, Inv. No. 337-TA-1168, Order No. 34, 2020 WL 1026335 (Feb. 14, 2020) (denying motion *in limine* to preclude testimony where: "[t]he invalidity theories at issue were previously disclosed at least in Dr. Lebby's expert report, and LSG had the opportunity to test these theories at Dr. Lebby's deposition.")

See case # 81 below

Patent litigation cases engaged:

1. Active case work: 1Q2009 (March 24th 2009); *Testimony: US-China Economic and security review commission on the optoelectronics industry. US Congress, Capitol Hill;* Written statement on the status of the USA optoelectronics industry with aural cross-examination by the commission. Trial experience.
    a. Deposition: 0 (Cumulative total: 0)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 1)
    c. Technology: Optoelectronics (optical storage, fiber optic communications, sensors, high power lasers, LED lighting, LED luminaires etc.).
2. Active case work: 3Q2010-1Q2011; *Finisar Corp. v. Optical Communication Products Inc.*, No. 10-CV-05617 and No. 11-cv-00104 (retained by plaintiff - Morgan, Lewis & Bockius LLP).
    a. Deposition: 0 (Cumulative total: 0)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 1)
    c. Technology: semiconductor lasers/VCSELs, fiber optic transceiver modules
3. Active case work: 1Q2011; *Ziptronix, Inc. v. OmniVision Technologies, Inc., Taiwan Semiconductor Manufacturing Company Ltd., and TSMC North America Corp.*, No. 11-CV-5235 (retained by plaintiff – Alston Bird LLP).
    a. Deposition: 0 (Cumulative total: 0)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 1)
    c. Technology: CMOS image sensors; design and fabrication
4. Active case work: 3Q2011 to 3Q2012; *Certain Light-Emitting Diodes and Products Containing Same*, Inv. No. 337-TA-798 (USITC filed July 15, 2011) (retained by respondent Samsung – Covington & Burling LLP). Deposition (x2) and trial experience.
    a. Deposition: 3 (Cumulative total: 3)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 2)
    c. Technology: LEDs, device design, color gamut, packaging, optical lensing, lead frames, surface mount packaging.
5. Active case work: 3Q2011 to 2Q2015; *Cheetah Omni, LLC v. Alcatel-Lucent USA Inc.*, No. 11-CV-390 (E.D. Tex. filed July 29, 2011) (retained by plaintiff – Brooks Kushman). Deposition experience (x2).
    a. Deposition: 1 (Cumulative total: 4)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 2)
    c. Technology: Fiber optic networks, optical switches, ROADMs and optical filters (dielectric based).
6. Active case work: 4Q2012 to 3Q2014**;** *Finisar Corp. v. Cheetah Omni, LLC*, No. 11-CV-15625 (E.D. Mich. filed Dec. 23, 2011) (retained by defendant – Brooks Kushman). Deposition experience (x1).
    a. Deposition: 1 (Cumulative total: 5)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 2)
    c. Technology: Wavelength optical switches, optical filters, and optical components, liquid crystal technology.
7. Active case work: 4Q2012 to 3Q2013**;** *Certain Optoelectronic Devices for Fiber Optic Communications, Components Thereof, and Prods. Containing the Same*, Inv. No. 337-TA-860 (USITC filed Sept. 24, 2012) (retained by respondent – Mellanox, IPtronics and FCI Inc and counsel Alston & Bird LLP). Deposition (x2) and trial experience.
    a. Deposition: 2 (Cumulative total: 7)

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   b. Trial/Hearing/Court appearance: 1 (Cumulative total: 3)
   c. Technology: IC design, layout, and operation; especially laser driver chips for VCSELs. High speed laboratory testing.
8. Active case work: 3Q2014 to 2Q2015**;** *Microscan Sys., Inc. v. Cognex Corp.*, No. 14-CV-6952 (S.D.N.Y. filed Aug. 27, 2014) (retained by plaintiff – Morrison & Foerster LLP). Deposition (x1) and trail experience.
   a. Deposition: 1 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 1 (Cumulative total: 4)
   c. Technology: Bar code scanners and associated optics such as imagers, lasers, LEDs, molded optics. Laboratory testing.
9. Active case work: 2Q2014 to 1Q2016**;** *Avago Techs. Fiber IP (Singapore) PTE Ltd. v. IPtronics Inc*., No. 10-CV-2863 (N.D. Cal. filed June 29, 2010) (retained by respondent – Alston & Bird LLP).
   a. Deposition: 0 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: IC design, layout, and operation; especially laser driver chips for VCSELs. High speed laboratory testing.
10. Active case work: 1Q2015 to 3Q2015; *Regarding certain optical disc drives*, Inv. No. 337-TA-897 (USITC filed Oct. 21, 2013) (retained by respondent – O'Melveny & Myers LLP).
   a. Deposition: 0 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: CD, CVD, BluRay optical disk drives, optical components, laser diodes, and optical beam patterns. Laboratory testing of visible optics.
11. Active case work: 1Q2015 to 2Q2015; *BMW of N. Am., LLC v. Innovative Display Techs., LLC*, No. IPR2015-00933, IPR2015-00934 (P.T.A.B. filed Mar. 24, 2015) (retained by plaintiff – Crowell Moring LLP).
   a. Deposition: 0 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: LED backlights for vehicles; LED package and optical module/LED luminaire design.
12. Active case work: 1Q2015 to 2Q2015; *BMW of N. Am., LLC v. Innovative Display Techs., LLC*, No. IPR2015-00934 (P.T.A.B. filed Mar. 24, 2015) (retained by plaintiff – Crowell Moring LLP).
   a. Deposition: 0 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: LED backlights for vehicles; LED package and optical module/luminaire design.
13. Active case work: 1Q2015 to 3Q2016; *OneChip Photonics Inc*., Pre-litigation IP Case No. TBD; (retained by plaintiff – Patent Monetization Inc. (PMI)).
   a. Deposition: 0 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: Photonic Integrated Circuits using InP (Indium Phosphide); lasers, detectors, waveguides, mux/demux, spot size converters.
14. Active case work: 2Q2016; *IDT v. Hyundai Motor Co.*, No. 14-CV-201 (E.D. Tex. filed May 4, 2015) (retained by defendant – DLA Piper LLP).
   a. Deposition: 0 (Cumulative total: 8)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: LED devices, packages and modules/luminaires for vehicles.
15. Active case work: 1Q2015 to 3Q2015; *Cree Inc., v. Honeywell Int'l Inc.,* No. 3:14-CV-737 (W.D. Wisc. filed Oct. 28, 2014) (retained by defendant - Arnold & Porter LLP). Deposition experience (x1).
   a. Deposition: 1 (Cumulative total: 9)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 4)
   c. Technology: LEDs for mobile phones; LED epitaxial layers, device designs, optical lensing, packaging. Laboratory reverse engineering using TEM/SEM/EDAX etc.
16. Active case work: 2Q2015 to 4Q2015; *Trs. of Boston Univ. v. Everlight Elecs. Co.*, Nos. 12-CV-11935, 12-CV-12326, 12-CV-12330 (D. Mass. filed Oct. 17, 2012) (retained by plaintiff - Shore Chan DePumpo LLP). Deposition (x1) and trial experience.
   a. Deposition: 1 (Cumulative total: 10)
   b. Trial/Hearing/Court appearance: 1 (Cumulative total: 5)
   c. Technology: GaN buffer layers for LEDs, and associated technical marketing, sales and import process into USA.
17. Active case work: 3Q2015 to 3Q2016; *LG Elecs. Inc. v. Toshiba Samsung Storage Tech. Corp.*, No. 12-CV-1063 (D. Del. filed Aug. 22, 2012) and IPR2015-01659 (PTAB filed Jul. 31st 2015 (retained by plaintiff – DLA Piper & Nixon Law). IPR deposition (i.e. trial) experience (x1).
   a. Deposition: 1 (Cumulative total: 11)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
   c. IPR/PTAB trial/deposition: 1 (Cumulative total: 1)
   d. Technology: Optical storage using laser diodes, photodetectors and optical materials

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18. Active case work: 3Q2015 to 3Q2016; *LG Elecs. Inc. v. Toshiba Samsung Storage Tech. Corp.*, No. 12-CV-1063 (D. Del. filed Aug. 22, 2012) and IPR2015-01642 (PTAB filed Jul. 30th 2015) (retained by plaintiff – DLA Piper & Nixon Law).
    a. Deposition: 0 (Cumulative total: 11)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 1)
    d. Technology: Optical storage using laser diodes, photodetectors and optical materials
19. Active case work: 3Q2015 to 3Q2016; *LG Elecs. Inc. v. Toshiba Samsung Storage Tech Corp.*, IPR2016-01677 (PTAB filed Aug. 24th 2016 (retained by plaintiff – DLA Piper & Nixon Law).
    a. Deposition: 0 (Cumulative total: 11)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 1)
    d. Technology: Optical storage using laser diodes, photodetectors and optical materials
20. Active case work: 3Q2015 to 3Q2016; *LG Elecs. Inc. v. Toshiba Samsung Storage Tech. Corp.*, IPR2015-01678 (PTAB filed Aug. 24th 2016) (retained by plaintiff – DLA Piper & Nixon Law).
    a. Deposition: 0 (Cumulative total: 11)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 1)
    d. Technology: Optical storage using laser diodes, photodetectors and optical materials
21. Active case work: 3Q2015 to 3Q2016; *LG Elecs. Inc. v. Toshiba Samsung Storage Tech. Corp.*, IPR2015-01644 (PTAB filed Jul. 30th 2015) (retained by plaintiff – DLA Piper & Nixon Law).
    a. Deposition: 0 (Cumulative total: 11)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 1)
    d. Technology: Optical storage using laser diodes, photodetectors and optical materials
22. Active case work: 3Q2015 to 3Q2016; *LG Elecs. Inc. v. Toshiba Samsung Storage Tech. Corp.*, IPR2015-01653 (PTAB filed Jul. 31st 2015) (retained by plaintiff – DLA Piper & Nixon Law).
    a. Deposition: 0 (Cumulative total: 11)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 1)
    d. Technology: Optical storage using laser diodes, photodetectors and optical materials
23. Active case work: 3Q2015; *Heptagon* Pre-litigation IPR petition; (retained by plaintiff – Proskaurer Rose LLP).
    a. Deposition: 0 (Cumulative total: 11)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 1)
    d. Technology: Proximity sensors using LEDs, photodetectors and innovative semiconductor packaging.
24. Active case work: 1Q2016 to 2Q2017; *Dentsply v. Am. Orthodontics Inc.*, No. 15-CV-1706 (D. Pa. filed Sept. 1, 2015) and IPR2016-01652 (PTAB filed Aug. 19th 2016) (retained by defendant – Godfrey Kahn LLP). IPR deposition (x1) experience.
    a. Deposition: 1 (Cumulative total: 12)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 2)
    d. Technology: High power lasers (YAG, CO2) to engrave and scribe dental orthodontic brackets.
25. Active case work: 2Q2016 to 2Q2017; *Koninklijke Philips N.V. v. Elect-tech Int'l (H.K.),* No. 14-CV-2737 (N.D. Cal. filed Aug. 12, 2015) (retained by plaintiff – Reed Smith LLP).
    a. Deposition: 0 (Cumulative total: 12)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 2)
    d. Technology: Trade secret MOCVD epitaxial growth techniques for high power GaN/InGaN LED technology, luminaires, modules and packaging.
26. Active case work: 2Q2016 to 4Q2016; *Bluestone Innovations llc. v. E. Mishan & Co. Inc.,* Pre-litigation IP Case No. TBD; (retained by defendant - Notaro, Michalos, & Zaccaria P.C.).
    a. Deposition: 0 (Cumulative total: 12)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 2)
    d. Technology: GaN/InGaN LEDs on structured substrates with reverse engineering laboratory analysis.
27. Active case work: 3Q2016-1Q2017; *511 Innovations Inc. v. HTC Am., Inc.*, No. 15-CV-1524 (E.D. Tex. Filed June 30, 2016) (retained by plaintiff – The Davis Firm). Deposition (x2)
    a. Deposition: 2 (Cumulative total: 14)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 2)
    d. Technology: Proximity sensors for mobile phones.
28. Active case work: 3Q2016-4Q2016; *Mellanox Techs. Ltd. v. Methode Elecs. Inc.*, No. 15-CV-3730 (N.D. Cal. filed Aug. 16, 2015) (retained by plaintiff – Alston & Bird).

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a. Deposition: 0 (Cumulative total: 14)
b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 2)
d. Technology: Fiber optic transceiver modules.

29. Active case work: 4Q2016-1Q2017; *Novanta Inc., v Iradion Inc*., No. 15-CV-01033 (D. Del. filed Nov. 9, 2015) (retained by defendant – Barnes and Thornburg LLP).
    a. Deposition: 0 (Cumulative total: 14)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 2)
    d. Technology: High power gas laser design and operation.
30. Active case work: 1Q2017-1Q2017; *Optolum Inc., v Cree Inc*., No. 16-CV-03828; (D. Az. filed Nov. 3, 2016) (retained by defendant – Jones Day).
    a. Deposition: 0 (Cumulative total: 14)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 2)
    d. Technology: LED packaging for illumination. LED luminaires.
31. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* 15-CV-00552 (W.D. NC. Filed: Apr 21st 2016), (retained by plaintiff - Troutman Sanders LLP). Deposition experience (x2)
    a. Deposition: 2 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
32. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* IPR2017-00309 (PTAB filed Nov. 21st 2017), (retained by plaintiff - Troutman Sanders LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
33. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* IPR2017-00330 (PTAB filed Nov. 24th 2017), (retained by plaintiff - Troutman Sanders LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
34. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* IPR2017-00331 (PTAB filed Nov. 24th 2017), (retained by plaintiff - Troutman Sanders LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
35. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* IPR2017-00332 (PTAB filed Nov. 25th 2017), (retained by plaintiff - Troutman Sanders LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
36. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* IPR2017-00334 (PTAB filed Nov. 25th 2017), (retained by plaintiff - Troutman Sanders LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
37. Active case work: 1Q2017-4Q2017; *Polygroup Macau Ltd (BVI)., v Willlis Electric Co., Ltd.,* IPR2017-00335 (PTAB filed Nov. 25th 2017), (retained by plaintiff - Troutman Sanders LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Electrical connector, IC, and LED light product design including luminaires.
38. Active case work: 1Q2017-4Q2017; *Macom Technology Solutions Holdings Inc., and Nitronex, LLC., v. Infineon Technologies AG and Infineon Technologies North American Corp*., 16-CV-02859 (C.D. Ca. filed Apr 26, 2016) (retained by plaintiff – Baker Botts LLP).
    a. Deposition: 0 (Cumulative total: 16)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)

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   d. Technology: High performance GaN based RF FET device design and operation.
39. Active case work: 1Q2017-1Q2017; *Quanergy Systems, Inc. v. Velodyne LiDAR, Inc.* (16-cv-05251; N.D. Ca. filed: Sep 13th 2016 (retained by plaintiff Velodyne) - Latham & Watkins LLP
   a. Deposition: 0 (Cumulative total: 16)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Laser/photodetector based LIDAR design and operation for self-driving vehicles.
40. Active case work: 1Q2017-2Q2017; *The Chamberlain Group Inc., v. Techtronic Industries Co., Ltd, Techtronic Industries North America et al.,* Challenge to U.S Patent No. 7,862,209 (retained by plaintiff – The Chamberlain Group) – Morgan, Lewis & Brockius, LLP.
   a. Deposition: 0 (Cumulative total: 16)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 5)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: LED based luminaire design for lighting.
41. Active case work: 1Q2017-1Q2018; *Uber Technologies Inc., Ottomottto LLC., Otto Trucking LLC., v. Waymo LLC (Google),* 17-CV-00939 (N.D. Ca filed: Mar 10th, 2017), (retained by defendant Uber Technologies Inc.) – Morrison and Foerster LLP. Deposition experience (x3) and trial experience (case settled at trial).
   a. Deposition: 3 (Cumulative total: 19)
   b. Trial/Hearing/Court appearance: 1 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Optical and electrical device, optics, and package designs for LIDAR based self-driving vehicles.
42. Active case work: 2Q2017-2Q2017; *Heptagon v. ST Mircoelectronics* IPR petition; (retained by plaintiff Heptagon) – Proskaurer Rose LLP).
   a. Deposition: 0 (Cumulative total: 19)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Optoelectronic based proximity sensors using LEDs and photodetectors.
43. Active case work: 2Q2017-2Q2018; *AT&T Inc., v. Sycamore Holdings LLC.*, 16-CV-00588 (E. D. Tx filed: Jun 6th 2016); (retained by defendant AT&T Inc.) - Kirkland and Ellis LLP. Deposition experience (x1)
   a. Deposition: 1 (Cumulative total: 20)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Coding designs of optical digital signals for high performance optical networks.
44. Active case work: 2Q2017 – 4Q2017; *Clearfield Inc., v. CommScope, ADC, Tyco, and TE Connectivity,* 17-CV-00307 (D.C. Minn. filed Jan 31st 2017); (retained by defendant Clearfield, Inc.) – Pepper Hamilton LLP
   a. Deposition: 0 (Cumulative total: 20)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Fiber optic connectors, panels, and distribution switches using optoelectronic components.
45. Active case work: 2Q2017 – 4Q2017; *Clearfield Inc., v. CommScope, ADC, Tyco, and TE Connectivity*, IPR2017-02122 (PTAB filed Sep. 15th 2017); (retained by defendant Clearfield, Inc.) – Pepper Hamilton LLP
   a. Deposition: 0 (Cumulative total: 20)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Fiber optic connectors, panels, and distribution switches using optoelectronic components.
46. Active case work: 2Q2017 – 4Q2017; *Clearfield Inc., v. CommScope, ADC, Tyco, and TE Connectivity*, IPR2018-00003 (PTAB filed Oct. 6th 2017); (retained by defendant Clearfield, Inc.) – Pepper Hamilton LLP
   a. Deposition: 0 (Cumulative total: 20)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Fiber optic connectors, panels, and distribution switches using optoelectronic components.
47. Active case work: 2Q2017 – 4Q2017; *Clearfield Inc., v. CommScope, ADC, Tyco, and TE Connectivity*, IPR2018-00154 (PTAB filed Nov. 7th 2017); (retained by defendant Clearfield, Inc.) – Pepper Hamilton LLP
   a. Deposition: 0 (Cumulative total: 20)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
   d. Technology: Fiber optic connectors, panels, and distribution switches using optoelectronic components.
48. Active case work: 4Q2016-2Q2017; *Antunes Inc.*, Pre-litigation IP patent review; Case No. TBD; (retained by plaintiff – Antunes Inc. and Chapman Spingola LLP).

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a. Deposition: 0 (Cumulative total: 20)
b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
d. Technology: High power grating surface emitter laser diodes, and associated packaging and device design for laser-based cooking ovens.

49. Active case work: 1Q2017-2Q2017; *Core Optical Technologies LLC. v. Fujitsu Network Communications, Inc.*, 16-CV-00437 (C. D. Ca filed: Mar 7th 2016); (retained by defendant Fujitsu Network Communications) – Morrison & Foerster LLP.
    a. Deposition: 0 (Cumulative total: 20)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Fiber optic based optical communications for coherent technologies
50. Active case work: 3Q2017-4Q2018; *Oyster Optics LLC v. Coriant America, et al*, 16-CV-01302 (E. D. Tx filed: Nov 24th 2016); (retained by plaintiff Oyster Optics LLC) – Russ August & Kabat LLP.
    a. Deposition: 1 (Cumulative total: 21)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Fiber optic based optoelectronic semiconductor component design and operation.
51. Active case work: 3Q2017-4Q2018; *Oyster Optics LLC v. Infinera, Alcatel-Lucent, Fujitsu, Cisco Systems, Huawei,* 16-CV-01295, 16-CV-01297, 16-CV-01299, 16-CV-01301, 16-CV-01303 (E. D. Tx filed: Nov 24th 2016); (retained by plaintiff Oyster Optics LLC) – Russ August & Kabat LLP. Deposition experience (x1).
    a. Deposition: 1 (Cumulative total: 22)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Fiber optic based optoelectronic semiconductor component design and operation. Including both direct detect and coherent communications, and encoding techniques such as PSK, QPSK, AM, FM etc.
52. Active case work: 3Q2017-4Q2017; *Olympus*, Pre-litigation IP and Due Diligence; Case No. TBD; (retained by plaintiff – Olympus and Fish & Richardson P.C.)
    a. Deposition: 0 (Cumulative total: 22)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: High volume, low cost optical lens and optics technology.
53. Active case work: 3Q2017-1Q2018; *Honeywell International, Inc et al v. Code Corporation et al.*, ITC No 337-TA-1061 (filed Jun 28th 2017), "Certain barcode readers, scan engines, products containing the same, and components thereof," (retained by respondent – Honeywell and Alston and Bird LLP
    a. Deposition: 1 (Cumulative total: 23)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Bar-code scanners and associated optical/optoelectronic component performance and operation.
54. Active case work: 4Q2017-1Q2019; *Godo Kaisha IP Bridge 1 v. Intel Corp.*, 17-CV-00676 (filed Sep 29th 2017), (retained by plaintiff – Godo Kaisha IP Bridge 1) - Ropes and Gray, LLP.
    a. Deposition: 0 (Cumulative total: 23)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 6)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Fabrication, design, and reverse engineering of silicon-based FET ICs.
55. Active case work: 4Q2017-3Q2018; *Maxim Integrated Products, Inc. and Volterra Semiconductor LLC., v. Silicon Mitus Inc., and Silicon Mitus Technology Inc.*, 17-CV-03507 (N. D. Ca: filed Jun 16th 2017), (retained by defendant Silicon Mitus) – Pillsbury Winthrop Shaw Pittman, LLP. (Deposition and trial experience X1)
    a. Deposition: 1 (Cumulative total: 24)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 7)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Fabrication, design, characterization, and packaging of silicon-based FET ICs for power applications
56. Active case work: 2Q2018-3Q2018; *Cree, Inc., v. Document Security Systems Inc.,* 17-CV-4263 (C.D. Ca filed: Apr 17th 2017), (retained by defendant Cree Inc.) - Jones Day, LLP
    a. Deposition: 0 (Cumulative total: 24)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 7)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Design and packaging of high brightness GaN based LEDs for luminaires.
57. Active case work: 2Q2018-2Q2018; Weisen v., Ram Telecom International (RTI)., CGC-16-554331 (Sup Ca: filed 3rd May 2017) (retained by plaintiff Weisen, J) - Yetter Coleman, LLP. Deposition experience (x1) and trial experience (x1).

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a. Deposition: 1 (Cumulative total: 25)
b. Trial/Hearing/Court appearance: 1 (Cumulative total: 8)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
d. Technology: Submarine and subsea fiber optic cables: technology, markets, economic impact, and history.

58. Active case work: 2Q2018-3Q2018; *Seoul Semiconductor., v. Document Security Systems Inc.,* 17-CV-00981 (C.D. Ca filed: Apr 17th 2017), (retained by defendant Seoul Semiconductor) - Latham and Watkins LLP
    a. Deposition: 1 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Design and packaging of high brightness GaN based LEDs for luminaires.
59. Active case work: 3Q2018-4Q2018; *NEC Display Solutions Inc., and NEC Display Solutions of America, Inc., v. Ultravision.,* ITC Case# 337-TA-1114 (filed 24th May 2018), "Certain Modular LED Display Panels and Components Thereof," (retained by respondent Jones Day, LLP)
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: Large LED Panels, LED displays, LED modular panel design, LED thermal engineering and color displays for outdoor environments.
60. Active case work: 3Q2018-3Q2018; IFT (Innovative Foundry Technologies) (pre-lit), retained by plaintiff Mintz Levin, Cohen, Ferris, Glovsky, and Popeo PC.)
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 3)
    d. Technology: CMOS device (inc FinFETs) and IC fabrication techniques at 40, 28, 20, 16nm nodes.
61. Active case work: 4Q2018-2Q2019; *Eidolon Optical LLC., v. Haag-Streit AG.,* IPR2018-01311, (retained by patent owner Eidolon Optical LLC) - McInnes & McLane LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 4)
    d. Technology: High brightness InGaAlP, GaP, AlGaAs, and GaN/InGaN based LEDs for use in medical instruments
62. Active case work: 3Q2018-3Q2018; *Voxtel Inc., v. Joseph Lachapelle & Luminar Technologies Inc.,* 18-CV-27356 (D. Or. filed: Dec 18th 2017), (retained by plaintiff Voxtel Inc.) - Ater Wynne LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LIDAR optical and electronic component and system technology
63. Active case work: 3Q2018-1Q2019; *Alta Devices, v. LG Electronics Inc.,* 18-CV-00404 (N.D. Ca. filed: May 7th 2018), (retained by defendant LG Electronics Inc.) - Hogan Lovells LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Trade Secret GaAs based solar cell design, fabrication, manufacturing, and device performance
64. Active case work: 3Q2018-3Q18; *Opterna AM Inc., v. Commscope Technologies Inc.,* Pre-litigation preparation, (retained by defendant Opterna AM Inc.) - Sterne Kessler LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Fiber optic connectors, panels, and distribution switches using optoelectronic components.
65. Active case work: 4Q2018 – 1Q2019; *U.D. Electronic Corp., v. Pulse Electronics, Inc.,* Preparation for IPR filing: IPR2019-00508 (PTAB filed Dec 26th 2018); and support for 18-CV-00373 (S.D. Ca. filed: Feb 16th 2018) (retained by petitioner U. D. Electronic Corp.) – Procopio, Cory, Hargreaves and Savitch LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Electrical and fiber optic connectors, panels, and distribution switches using both electronic and optoelectronic components.
66. Active case work: 4Q2018 – 1Q2019; *U.D. Electronic Corp., v. Pulse Electronics, Inc.,* Preparation for IPR filing: IPR2019-00515 (PTAB filed Dec 31st 2018); and support for 18-CV-00373 (S.D. Ca. filed: Feb 16th 2018) (retained by petitioner U. D. Electronic Corp.) – Procopio, Cory, Hargreaves and Savitch LLP
    a. Deposition: 0 (Cumulative total: 26)

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b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
d. Technology: Electrical and fiber optic connectors, panels, and distribution switches using both electronic and optoelectronic components.

67. Active case work: 4Q2018 – 1Q2019; *U.D. Electronic Corp., v. Pulse Electronics, Inc.*, Preparation for IPR filing: IPR2019-00262 (PTAB filed Nov 9th 2018); and support for 18-CV-00373 (S.D. Ca. filed: Feb 16th 2018) (retained by petitioner U. D. Electronic Corp.) – Procopio, Cory, Hargreaves and Savitch LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Electrical and fiber optic connectors, panels, and distribution switches using both electronic and optoelectronic components.
68. Active case work: 4Q2018 – 1Q2019; *U.D. Electronic Corp., v. Pulse Electronics, Inc.*, Preparation for IPR filing: IPR2019-00511 (PTAB filed Dec 28th 2018); and support for 18-CV-00373 (S.D. Ca. filed: Feb 16th 2018) (retained by petitioner U. D. Electronic Corp.) – Procopio, Cory, Hargreaves and Savitch LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Electrical and fiber optic connectors, panels, and distribution switches using both electronic and optoelectronic components.
69. Active case work: 4Q2018 – 1Q2019; *Semiconductor Energy Laboratory Co. Ltd., v. Bluehouse Global Ltd.*, Preparation for IPR filing: IPR2018-01405 (PTAB filed Jul 18th 2018); (retained by patent owner SEL Co Ltd.) – Robinson Intellectual Law Office, P.C. (Counsel represented by Fish and Richardson LLP).
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Semiconductor displays using active matrix LCD and thin film transistor technology. Design, fabrication, and circuit layout.
70. Active case work: 4Q2018 – 1Q2019; *Semiconductor Energy Laboratory Co. Ltd., v. Bluehouse Global Ltd.*, Preparation for IPR filing: IPR2018-01393 (PTAB filed Jul 13th 2018); (retained by patent owner SEL Co Ltd.) – Robinson Intellectual Law Office, P.C. (Counsel represented by Fish and Richardson LLP)
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 8)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Semiconductor displays using active matrix LCD and thin film transistor technology. Design and fabrication technology.
71. Active case work: 4Q2018 - 1Q2019; *The Sloan Company dba SloanLED, v. Principle Lighting Group, LLC.*, 18-CV-06449 (C.D. Ca. filed: Jul 26th 2018), (retained by defendant Sloan LED.) - Ferguson Case Orr Paterson LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED lighting, LED luminaires, LED performance, electrical and mechanical design and construction.
72. Active case work: 1Q2019 - 1Q2019; *HTC Corporation, v. Lemire Illumination Technologies.,* 18-CV-00021 (E.D. Tx. filed: Jan 21st 2018), (retained by defendant HTC Corporation) - Perkins Coie LLP
    a. Deposition: 0 (Cumulative total: 26)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LEDs for mobile phones
73. Active case work: 1Q2019 - 2Q2019; *Frys Electronics, v. Seoul Semiconductor Co, and Seoul Viosys Co.,*, 2:18-CV-00386-JRG (E. D. Tx. filed: Nov 20th 2018), (retained by defendant Frys Electronics) - Lamkin IP Defense
    a. Deposition: 0 (Cumulative total: 26),
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED chips, LED packaging, LED lenses, LED luminaires, backlights, displays, and televisions/monitors
74. Active case work: 2Q2019 – 4Q2019; *Hanwha Q CELLS & Advance Materials Corporation, v. JinkoSolar, LONGi Solar, REC Solar*, ITC 337-TA-1151 (filed: Apr 4th 2019), ("Certain Photovoltaic Cells and Products Containing Same,"), retained by patent owner and plaintiff Hanwha Q CELLS) - Covington and Burling LLP
    a. Deposition: 2 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)

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75. Active case work: 2Q2019-3Q2019; *Hanwha Q CELLS & Advance Materials Corporation, v. JinkoSolar and affiliates*, 19-CV-00450 (D. Del. filed: Jan 21st 2018), (retained by patent owner and plaintiff Hanwha Q CELLS) - Covington and Burling LLP
    a. Deposition: 0 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Silicon solar cells and materials analysis of passivation layers
76. Active case work: 2Q2019-2Q2019; *Oyster Optics LLC v. Infinera Inc*, 2:18-CV-00206 (E. D. Tx filed: May 15th 2018); (retained by plaintiff Oyster Optics LLC) – Russ August & Kabat LLP.
    a. Deposition: 0 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Fiber optic based optoelectronic semiconductor component and transceiver design/ operation.
77. Active case work: 2Q2019 – 2Q2019; *Nichia Corporation & Osram Opto Semiconductors Inc., v. Lighting Science Group Corp.*, IPR filing: IPR2019-01259 (PTAB filed Jun 28th 2019); (retained by petitioner Nichia and Osram Opto.) – Shearman and Sterling, LLP
    a. Deposition: 0 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED chips, LED packaging and ceramic thermal heat sinking technology.
78. Active case work: 2Q2019 – 3Q2019; *Nichia Corporation v. Lighting Science Group Corp.*, 2:17-CV-08849 (C. D. Ca filed Jul 12th 2017); (retained by defendant Nichia) – Shearman and Sterling, LLP
    a. Deposition: 0 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED chips, LED packaging and ceramic thermal heat sinking technology
79. Active case work: 3Q2019-3Q2019; *Applied Optoelectronics Inc v. Class Action Lawsuit*, 4:17-CV-02399 (S. D. Tx filed: Mar 6th 2018); (retained by plaintiff Class Action Lawsuit) – Levi and Korsinsky, LLP
    a. Deposition: 0 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: Fiber optic based optoelectronic semiconductor components, transceivers, and sub-systems.
80. Active case work: 3Q2019-3Q2019; *DNA Motor v. Kuen Hwa Traffic Industrial Co.*, 18-CV-05664 (C. D. Ca filed: Jan 15th 2019); (defendant DNA Motor) – Elizabeth Yang, Law and Mediation Office
    a. Deposition: 0 (Cumulative total: 28)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 9)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED design patent, and the design of an aftermarket LED based headlight assembly for an automobile.
81. Active case work: 3Q2019 – 1Q2020; *Nichia Corporation, Osram Opto Semiconductors Inc., Philips Lumileds, GE Consumer Lighting, Cree, and Signify v. Lighting Science Group Corp.*, ITC 337-TA-1168 (filed: Apr 30th 2019), ("Certain Light-Emitting-Diode products, systems, and components thereof (III)") (retained by respondents Nichia, Osram Optoelectronics, Philips Lumileds, GE Consumer Lighting, Cree Hong Kong., Signify Corp.) – Shearman and Sterling, LLP
    a. Deposition: 1 (Cumulative total: 29)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 10)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED chips, LED packaging and ceramic thermal heat sinking technology (LTCC).
82. Active case work: 4Q2019 – 1Q2020; *Amazon.com Inc, Bed, Bath and Beyond, IKEA, Target, and Walmart Inc., v. Regents of the University of California*, ITC 337-TA-1172 (filed: July 30th 2019), ("Certain Filament Light-Emitting-Diodes and products containing same") (retained by respondents Amazon.com Inc, Bed, Bath and Beyond, IKEA, Target, and Walmart Inc.) – Morrison and Foerster, LLP
    a. Deposition: 2 (Cumulative total: 31)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
    d. Technology: LED chips, LED packaging and light bulb filaments with transparent sub-mounts.
83. Active case work: 4Q2019 – 4Q2019; *U.D. Electronic Corp., v. Pulse Electronics, Inc.*, IPR2019-00511 (PTAB filed Dec 28th 2018), (retained by petitioner U. D. Electronic Corp.) – Procopio, Cory, Hargreaves and Savitch LLP
    a. Deposition: 0 (Cumulative total: 31)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)

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   d. Technology: Electrical and fiber optic connectors, panels, and distribution switches using both electronic and optoelectronic components.

84. Active case work: 1Q2020 – 2Q2020; *IKEA, v. Regents of the University of California*, ITC 337-TA-1172 (filed: July 30th 2019), ("Certain Filament Light-Emitting-Diodes and products containing same") (retained by respondents IKEA) – Flaster and Greenberg, LLP
   a. Deposition: 2 (Cumulative total: 31)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: LED chips, LED packaging and light bulb filaments with transparent sub-mounts.
85. Active case work: 1Q2020-1Q2020; *Hanwha Solutions Corporation, v. Longi Green Energy, Longi Solar Technology, Longi Trading et al.*, IPR2019-01072 (PTAB filed 13th May 2019), (retained by patent owner Hanwha Solutions Corporation) - Covington and Burling LLP
   a. Deposition: 0 (Cumulative total: 31)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: Silicon solar cells and materials analysis of passivation layers
86. Active case work: 1Q2020-1Q2020; *Hanwha Solutions Corporation, v. REC Solar Pte. Ltd. and JinkSolar (U.S.) Inc.* IPR2019-01145 (PTAB filed 6th March 2019), (retained by patent owner Hanwha Solutions Corporation) - Covington and Burling LLP
   a. Deposition: 0 (Cumulative total: 31)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: Silicon solar cells and materials analysis of passivation layers
87. Active case work: 4Q2019 – 2Q2020; *Viavi Solutions Inc., v Optrontec Inc.,* ITC 337-TA-1187 (filed: 18th November 2019), ("Certain Electronic devices with Optical Filters and Optical Sensor Systems and Components Thereof") (retained by complainant Viavi Solutions Inc.,) – Venable, LLP
   a. Deposition: 0 (Cumulative total: 31)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: Optical filters and optical sensor systems, design and fabrication of dielectric materials for passband filters in applications such as optical communications, imaging, sensing, medical, automotive.
88. Active case work: 2Q2020 – 4Q2020; *Leviton Manufacturing Co., v. Corning Optical Communications LLC.*, ITC 337-TA-1194 (filed: 19th March 2020), ("Certain High-Density Fiber Optic Equipment and Components Thereof") (retained by respondent Leviton Manufacturing Co.,) – Morrison & Foerster, LLP
   a. Deposition: 1 (Cumulative total: 32)
   b. Trial/Hearing/Court appearance: 1 (Cumulative total: 11)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: Fiber optic adapters, fiber optic connectors (simplex, duplex, quad, multi-fiber), fiber trays, racks, and fiber cabinet equipment.
   e. Technology: LED chips, LED packaging and light bulb filaments with transparent sub-mounts.
89. Active case work: 2Q2020 – 2Q2020; subject to PO/NDA and engagement letter *xxx v. yyy*, Post Grant Review petition for proceedings (US Patent # zzz), retained by Morrison and Foerster, LLP
   a. Deposition: 0 (Cumulative total: 31)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 10)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Optoelectronics, LEDs, lead frame packaging, optics, optical lenses, GaN (Gallium Nitride), optical transparency
90. Active case work: 1Q2020-3Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc.*, IPR2020-00560 (PTAB filed 16th Feb 2020), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
   a. Deposition: 0 (Cumulative total: 32)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 11)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: Silicon CMOS image sensors, drive electronics, smart pixels and CCD technology
91. Active case work: 2Q2020-2Q2020; *Panasonic, v. 3M Innovative Properties Company*., Preparation for IPR filing, (retained by defendant Panasonic) – retained by Westerman Hattori Daniels & Adrian LLP
   a. Deposition: 0 (Cumulative total: 32)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 11)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 4)
   d. Technology: Touch sensor (resistive, optical, and capacitive) technology for mobile displays. Analysis of display, electronic, and optical technologies.

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92. Active case work: 2Q2020-3Q2020; *Longi Green Energy Technology Co, Longi Solar Technology Co, Long Solar Technology (H.K., Kuching, Taizhou, Zhejiang, Hefei, US) v. Hanwha Solutions Corporation*., IPR 2019-01072, (retained by patent owner Hanwha Solutions Corporation) – Quinn Emanuel Urquhart & Sullivan, LLP
    a. Deposition: 1 (Cumulative total: 33)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 11)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 5)
    d. Optoelectronics; solar cell design, fabrication, device performance, packaging, and interface issues relating to passivation (both chemical and electric field enhanced).
93. Active case work: 3Q2020-3Q2020; *Oyster Optics LLC v. Ciena Corp*, 4:17-CV-05920 (N. D. CA filed: April 22nd 2020); (retained by plaintiff Oyster Optics LLC) – Russ August & Kabat LLP.
    a. Deposition: 0 (Cumulative total: 33)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 12)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 5)
    d. Technology: Fiber optic based optoelectronic semiconductor component design and operation, especially phase shift keying (PSK, QPSK) and phase based coherent communications.
94. Active case work: 3Q2020-2Q2021; *Capella Photonics Inc., v. Infinera Corporation, Tellabs, Tellabs Operations Inc., Coriant American Inc., and Coriant USA Inc., 2*:20-CV-00077 (E. D. TX filed: March 16th 2020); (retained by defendant Infinera Inc.) – Baker Botts LLP.
    a. Deposition: 1 (Cumulative total: 34)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 12)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 5)
    d. Technology: Fiber optic wavelength selective switches (WSS), reconfigurable add-drop multiplexors (ROADMs), and their design. Technical issues include polarization, wavelength selection, coupling, mux/demux and operation in optical networks.
95. Active case work: 3Q2020-3Q2020; *Longi Green Energy Technology Co, Longi Solar Technology Co, Long Solar Technology (H.K., Kuching, Taizhou, Zhejiang, Hefei, US) v. Hanwha Solutions Corporation*., IPR 2020-00353, (retained by patent owner Hanwha Solutions Corporation) – Quinn Emanuel Urquhart & Sullivan, LLP
    a. Deposition: 0 (Cumulative total: 34)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 12)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 6)
    d. Optoelectronics: solar cell design, fabrication, device performance, packaging, and interface issues relating to passivation (both chemical and electric field enhanced).
96. Active case work: 3Q2020-2Q2021; *Appotronics Corporation Ltd. v. Delta Electronics Inc., 2*:19-CV-00466 (E. D. Va filed: July 22nd 2020); (retained by defendant Delta Corporation Inc) – Pillsbury Winthorp Shaw Pitman LLP.
    a. Deposition: 1 (Cumulative total: 35)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 12)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Light projectors for display and the color wheel, phosphor technology, high power visible lasers for projection, and the associated packaging of the modules/projectors for efficient cost design..
97. Active case work: 3Q2020 – 2Q2021; *Ideal Industries Lighting LLC (dba Cree Lighting) v. RAB Lighting Inc.,* ITC 337-TA-1213 (filed: 15th July 2020), ("Certain Light-emitting Diode Products, Fixtures, and Components thereof"), (retained by plaintiff Ideal Industries Lighting LLC (dba Cree Lighting) – Quinn Emanuel Urquhart an Sullivan, LLP
    a. Deposition: 1(Cumulative total: 36)
    b. Trial/Hearing/Court appearance: 2(twice at the stand); (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Visible GaN based LEDs and various packaging optical lens designs for directing and re-directing LED light output with applications in street lighting.
98. Active case work: 3Q2020-3Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc., ex parte* declaration entitled, 'Hand-held computers incorporating reduced area imaging devices', for U.S. Patent 6,982,742 (control number 90/014,453), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
    a. Deposition: 0 (Cumulative total: 36)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Hand-held silicon CMOS image sensors, drive electronics, smart pixels and CCD technology. Technical history of CCD v. CMOS image sensors in the 1990s and associated performance criteria.
99. Active case work: 3Q2020-3Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc., ex parte* declaration entitled, 'Communication devices incorporating reduced area imaging devices', for U.S. Patent 6,452,626 (control number 90/014,455), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
    a. Deposition: 0 (Cumulative total: 36)

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b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
d. Technology: Hand-held silicon CMOS image sensors, drive electronics, smart pixels and CCD technology. Technical history of CCD v. CMOS image sensors in the 1990s and associated performance criteria.

100. Active case work: 4Q2020-4Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc.*, IPR declaration for U.S. Patent 9,198,565 (IPR2020-00476), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
    a. Deposition: 0 (Cumulative total: 36)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Hand-held silicon CMOS image sensors, drive electronics, smart pixels and CCD technology. Technical history of CCD v. CMOS image sensors in the 1990s and associated performance criteria.
101. Active case work: 4Q2020-4Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc.*, IPR declaration for U.S. Patent 9,667,896 (IPR2020-00477), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
    a. Deposition: 0 (Cumulative total: 36)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Hand-held silicon CMOS image sensors, drive electronics, smart pixels and CCD technology. Technical history of CCD v. CMOS image sensors in the 1990s and associated performance criteria.
102. Active case work: 4Q2020 – 1Q2021; *U.D. Electronic Corp., v. Pulse Electronics, Inc.*, 3:18-CV-00373 (Filed Fed 16th 2018), (retained by petitioner U. D. Electronic Corp.) – retained by defendant Perkins Coie LLP.
    a. Deposition: 1 (Cumulative total: 37)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Electrical and fiber optic connectors, panels, and distribution switches using both electronic and optoelectronic components. Noise suppression using EMI between electrical components and connectors.
103. Active case work: 4Q2020-4Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc.*, IPR declaration for U.S. Patent 9,186,052 (IPR2020-00512), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
    a. Deposition: 1 (Cumulative total: 38)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Hand-held silicon CMOS image sensors, drive electronics, smart pixels and CCD technology. Technical history of CCD v. CMOS image sensors in the 1990s and associated performance criteria.
104. Active case work: 4Q2020-4Q2020; *Cellect LLC, v. Samsung Electronics Co., LTD and Samsung Electronics America, Inc.*, IPR declaration for U.S. Patent 9,186,052 (IPR2020-00475), (retained by patent owner Cellect LLC) – retained by Kramer Levin Naftalis & Frankel LLP
    a. Deposition: 1 (Cumulative total: 39)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Hand-held silicon CMOS image sensors, drive electronics, smart pixels and CCD technology. Technical history of CCD v. CMOS image sensors in the 1990s and associated performance criteria.
105. Active case work: 3Q2020 – 1Q2021; *Huawei Technologies Co. Ltd. v. Verizon Communications, Inc., et al.*, 20-CV-030-JRG (TX E. D. Filed 2nd April 2020), (retained by plaintiff Huawei Technologies Co. Ltd.) – retained by plaintiff Caldwell Cassady Curry P.C.
    a. Deposition: 0 (Cumulative total: 39)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 14)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Analysis of coding for fiber optic communications, specifically in relation to the standardization process for the Telecommunication Standardization Sector of the International Telecommunications Union ("ITU-T"), including the ITU-T's G.709: Interfaces for the optical transport network standard ("G.709" or "the G.709 Standard"). In particular, the technical issues that relate to OTN hierarchy; functionality of the overhead in support of multi-wavelength optical networks; frame structures, bit rates, and formats for mapping client signals.
106. Active case work: 1Q2021 – 3Q2021; *IKEA et al., v. Regents of the University of California*, ITC 337-TA-1220 (filed: 29th September 2020), ("Certain filament light-emitting diodes and products containing same (II)"), (retained by respondent JDG: IKEA, Global Value Lighting, Signify, Home Depot, GE, Satco) – retained by

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Flaster Greenberg PC, Kirkland and Ellis, GT Law, Alston and Bird, Jones Day and Goodwin Law as JDG counsel.

a. Deposition: 2 (Cumulative total: 41)
b. Trial/Hearing/Court appearance: 1 (Cumulative total: 15)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
d. Technology: LED chips, LED packaging and light bulb filaments with transparent sub-mounts.

107. Active case work 4Q2020 – 1Q2021; *Uber Technologies Inc., v. Anthony Scott Levandowski*; Case No. 20-30242 (HLB) and 20-03050 (filed 16th September 2020), retained by defendant Uber Technologies Inc., retained by Jenner and Block LLP.
    a. Deposition: 0 (Cumulative total: 41)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 15)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: LIDAR technology for motor vehicles that includes fiber amplifiers, LIDAR hardware, laser diodes, photodetectors, fiber links, and free space communications.
108. Active case work: 1Q2021 – 3Q2021; *CoSemi Technologies, v. Everpro Technologies, Fibbr Technologies, Logitech, and Facebook Technologies*, ITC 337-TA-1233 (filed: 29th October 2020), "Certain active optical cables and products containing same", (retained by claimant Cosemi Technologies) – retained by Rutan & Tucker LLP.
    a. Deposition: 1 (Cumulative total: 42)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 15)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Active optical cables with embedded silicon modulator ICs, copper cable, fiber optic cable, VCSEL laser diodes, photodetectors and cable sheathing for consumer applications such as gaming, HDMI, USB, etc.
109. Active case work: 2Q2021 – 3Q2021; *Acuity Brands Lighting ,Inc. v. Heavy Duty Lighting (HDL), LLC.*, 20-CV-03648-SCJ (GA N. D. Filed 2nd September 2020), (retained by defendant Acuity Brands Lighting) – retained by defendant Duane Morris LLP.
    a. Deposition: 1 (Cumulative total: 43)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 15)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: LED lighting, LED chips, LED packages and LED packaging technologies such as molding, glob-top, substrates, die mounting, optical reflectors, and electrical interconnect layouts.
110. Active case work: 2Q2021 – 4Q2021; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. CH Lighting Technology co., LTD., Elliott Electric Supply Inc., and Shaoxing Ruising Lighting co., Ltd.*, 20-CV-00018-ADA (TX W D. Filed 16th March 2020), (retained by defendant CH Lighting et al) – retained by defendant Holland and Knight LLP.
    a. Deposition: 1 (Cumulative total: 44)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 16)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
111. Active case work: 3Q2021 – 1Q2022; ASUSTEK Computer Inc, *v. KT Imaging USA LLC*, 20-CV-00300-ADA (TX W D. Filed 20th April 2020, (retained by defendant ASUSTEK Computer Inc) – retained by defendant Turner Boyd LLP.
    a. Deposition: 0 (Cumulative total: 44)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 16)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Image sensor modules, cameras in PCs/laptops, consumer products, tear downs, optical lenses, optical packaging, optical alignment.
112. Active case work: 3Q2021 – 3Q2021; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Maxlite Inc.*, 19-CV-04047 (CA C.D. Filed 8th May 2019), (retained by defendant Maxlite Inc) – retained by defendant Holland and Knight LLP.
    a. Deposition: 0 (Cumulative total: 44)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 16)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
113. Active case work: 3Q2021 – 1Q2023; *Feit Electric Company Inc., v. Nichia Corporation*, 20-CV-00359-GW, (CA C. D. Filed 13th January 2020), (retained by defendant Feit Electric Company) – retained by Benesch Friedlander Coplan &Aronoff LLP
    a. Deposition: 2 (Cumulative total: 46)
    b. Trial/Hearing/Court appearance: 2 (Cumulative total: 18)

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c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
d. Technology: LED lighting, LED chips, LED packages and LED packaging technologies such as lead-frames, molding, glob-top, substrates, die mounting, optical reflectors, and electrical interconnect layouts.

114. Active case work: 2Q2021 – 2Q2022; *Samsung Corporation vs TBD*, Pre-patent litigation, (retained by plaintiff Samsung Corporation), - retained by Quinn Emanuel Urquhart & Sullivan, LLP).
    a. Deposition: 0 (Cumulative total: 46)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: TV displays, OLEDs, LCDs, color gamut, and quality of RGB/white color as per CIE charts and colorimetry (NTSC, sRGB, AdobeRGB etc,.). Analysis of CHL (constant hue locus), quantum dots, nano-crystals, nano-devices, nano-structures to improve light quality output.
115. Active case work 2Q2021 – 2Q2021, *Holochip Corporation v, Edmund Optics, Optotune AG and others TBD*, Pre-patent litigation for ITC, (retained by plaintiff Holochip Corporation), - retained by King and Spalding LLP).
    a. Deposition: 0 (Cumulative total: 46)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 6)
    d. Technology: Fluid lenses, and optical lenses with controlled focus facilities. Packaging of fluid lenses using piezoelectric actuators, and hermetic chambers. Deformable surfaces using micro-fluidics.
116. Active case work: 2Q2021-3Q2021; *Home Depot USA Inc., v. Lynk Labs, Inc.*, IPR declaration for U.S. Patent 10,757,783 (IPR2021-01368), (retained by petitioner Home Depot USA, Inc) – retained by DLA Piper LLP
    a. Deposition: 1 (Cumulative total: 47)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 7)
    d. Technology: LED products, LED circuits, including both DC and AC circuit design. LED color emission, white light, color mixing, CIE charts, and black body radiators for color temperature.
117. Active case work: 2Q2021-3Q2021; *Home Depot USA Inc., v. Lynk Labs, Inc.*, IPR declaration for U.S. Patent 10,492,251 (IPR2021-01369), (retained by petitioner Home Depot USA, Inc) – retained by DLA Piper LLP
    a. Deposition: 1 (Cumulative total: 48)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 8)
    d. Technology: LED products, LED circuits, including both DC and AC circuit design. LED color emission, white light, color mixing, CIE charts, and black body radiators for color temperature.
118. Active case work: 3Q2021-3Q2021; *Home Depot USA Inc., v. Lynk Labs, Inc.*, IPR declaration for U.S. Patent 10,091,842 (IPR2021-01540), (retained by petitioner Home Depot USA, Inc) – retained by DLA Piper LLP
    a. Deposition: 1 (Cumulative total: 49)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 9)
    d. Technology: LED products, LED circuits, including both DC and AC circuit design. LED color emission, white light, color mixing, CIE charts, and black body radiators for color temperature.
119. Active case work: 4Q2021-4Q2021; *Home Depot USA Inc., v. Lynk Labs, Inc.*, IPR declaration for U.S. Patent 10,517,149 (IPR2022-000023), (retained by petitioner Home Depot USA, Inc) – retained by DLA Piper LLP
    a. Deposition: 1 (Cumulative total: 50)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 1 (Cumulative total: 10)
    d. Technology: LED products, LED circuits, including both DC and AC circuit design. LED color emission, white light, color mixing, CIE charts, and black body radiators for color temperature.
120. Active case work: 4Q2021-Present; *Everlight Elecs. Co. Ltd. v. Amazon.com, Inc. et al.*, 6:21-CV-00906 (W. D. TX filed: August 31st 2021); (retained by defendant Amazon.com) – Morrison and Foerster LLP.
    a. Deposition: 0 (Cumulative total: 50)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 18)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 10)
    d. Technology: LED chips, LED packaging with metallic electrodes, flip-chip solder bumping, and doping of semiconductors for electrical conduction.
121. Active case work: 4Q2021-2Q2021; *Hanwha Solutions Corporation and affiliated companies including Q-Cells, Boviet Renewable Power, Boviet Solar, Canadian Solar International v. Advanced Silicon Group Technologies*, ITC 337-TA-1271 (filed: 14th October 2020) "Certain silicon photovoltaic cells and modules with nanostructures, and products containing the same." (retained by joint defense group consisting of Quinn Emanual Urquhart & Sullivan, LLP., Morgan Lewis and Bockius, LLP., and Sidley Austin LLP.).
    a. Deposition: 2 (Cumulative total: 52)
    b. Trial/Hearing/Court appearance: 1 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 10)

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   d. Technology: Silicon based solar/photovoltaic cells and modules that include fabrication techniques such as deposition, diffusion, wet/dry etching of nanostructures, nanowires, and nano-structures, nano-features, black silicon, monocrystalline wafers, and polysilicon fabrication.

122. Active case work: 4Q2021-2Q2022; *Dell Computer Inc, v. KT Imaging USA LLC,* Declaration for IPR with patent number 6,876,544 as petitioner, (to be filed), (retained by defendant Dell Computer Inc) – retained by petitioner Farella, Braun, and Martel.
   a. Deposition: 0 (Cumulative total: 52)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 10)
   d. Technology: Image sensor modules, cameras in PCs/laptops, consumer products, tear downs, optical lenses, optical packaging, optical alignment.
123. Active case work: 1Q2022-2Q2022; *Cree Lighting, Wolfspeed, Ideal Industries Lighting, v. CAO Lighting,* Declaration for IPR with patent number 6,465,961 as petitioner, (filed 8th April 2022), (retained by defendant Cree Lighting) – retained by Kilpatrick Townsend & Stockton LLP.
   a. Deposition: 2 (Cumulative total: 54)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 2 (Cumulative total: 12)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, active regions, cladding layers, optical mirrors, DBRs
124. Active case work: 1Q2022-2Q2022; *Cree Lighting, Wolfspeed, Ideal Industries Lighting, v. CAO Lighting,* Declaration for IPR with patent numbers 6,634,770 as petitioner, (filed 8th April 2022), (retained by defendant Cree Lighting) – retained by Kilpatrick Townsend & Stockton LLP.
   a. Deposition: 1 (Cumulative total: 55)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 1 (Cumulative total: 13)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, active regions, cladding layers, optical mirrors, DBRs
125. Active case work: 1Q2022-2Q2022; *Cree Lighting dba Ideal Industries Lighting, v. CAO Lighting,* 1:21-cv-00634 (MD NC filed 12th Aug 2021,), (retained by defendant Cree Lighting) – retained by Kilpatrick Townsend & Stockton LLP.
   a. Deposition: 0 (Cumulative total: 55)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 13)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, active regions, cladding layers, optical mirrors, DBRs
126. Active case work: 1Q2022-2Q2022; *Lite-On Technology Corporation and Genesis Photonics Inc., v. Sensor Electronic Technology Inc., (SETi),* 6:21-cv-00322 (WD Tex filed 12th Aug 2021,), (retained by plaintiff LiteOn and Genesis) – retained by Pillsbury Winthrop Shaw Pittman LLP.
   a. Deposition: 0 (Cumulative total: 55)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 13)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, flip-chip packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, GaN fabrication, LED quantum well active regions, LEDcladding layers, optical mirrors, DBRs
127. Active case work: 1Q2022-2Q2022; *Lite-On Technology Corporation and Genesis Photonics Inc., v. Sensor Electronic Technology Inc., (SETi),* Declaration for IPR (IPR2022-00395) as patent owner, (retained by plaintiff LiteOn and Genesis) – retained by Pillsbury Winthrop Shaw Pittman LLP.
   a. Deposition: 2 (Cumulative total: 57)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 2 (Cumulative total: 15)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, flip-chip packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, GaN fabrication, LED quantum well active regions, LED cladding layers, optical mirrors, DBRs
128. Active case work: 1Q2022-2Q2022; *Lite-On Technology Corporation and Genesis Photonics Inc., v. Sensor Electronic Technology Inc., (SETi),* Declaration for IPR (IPR2022-00396) as patent owner, (retained by plaintiff LiteOn and Genesis) – retained by Pillsbury Winthrop Shaw Pittman LLP.
   a. Deposition: 0 (Cumulative total: 57)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 15)

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   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, flip-chip packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, GaN fabrication, LED quantum well active regions, LED cladding layers, optical mirrors, DBRs

129. Active case work: 1Q2022-2Q2022; *Lite-On Technology Corporation and Genesis Photonics Inc., v. Sensor Electronic Technology Inc., (SETi)*, Declaration for IPR (IPR2022-00397) as patent owner, (retained by plaintiff LiteOn and Genesis) – retained by Pillsbury Winthrop Shaw Pittman LLP.
   a. Deposition: 0 (Cumulative total: 57)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 15)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, flip-chip packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, GaN fabrication, LED quantum well active regions, LED cladding layers, optical mirrors, DBRs
130. Active case work: 1Q2022-2Q2022; *Lite-On Technology Corporation and Genesis Photonics Inc., v. Sensor Electronic Technology Inc., (SETi)*, Declaration for IPR (IPR2022-00406) as patent owner, (retained by plaintiff LiteOn and Genesis) – retained by Pillsbury Winthrop Shaw Pittman LLP.
   a. Deposition: 0 (Cumulative total: 57)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 15)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, flip-chip packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, GaN fabrication, LED quantum well active regions, LED cladding layers, optical mirrors, DBRs
131. Active case work: 1Q2022-2Q2022; *Lite-On Technology Corporation and Genesis Photonics Inc., v. Sensor Electronic Technology Inc., (SETi)*, Declaration for IPR (IPR2022-00419) as patent owner, (retained by plaintiff LiteOn and Genesis) – retained by Pillsbury Winthrop Shaw Pittman LLP.
   a. Deposition: 1 (Cumulative total: 58)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 1 (Cumulative total: 16)
   d. Technology: LED based light bulbs, LED chips, LED arrays, LED packaging, flip-chip packaging, chip-on-board, heat sinks, GaN, InGaN, AlGaN (Gallium Nitride, Indium Gallium Nitride, Aluminum Gallium Nitride) epitaxial layers, GaN fabrication, LED quantum well active regions, LED cladding layers, optical mirrors, DBRs
132. Active case work: 1Q2022-3Q2022; *Panasonic Corporation, v. Magna International Inc.*, 21-cv-00319 (WD Tex filed 31st Mar 2021,), (retained by plaintiff Panasonic) – retained by Sidley Austin LLP.
   a. Deposition: 0 (Cumulative total: 58)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: Automotive sensors, cameras, electronic circuitry, controls, packaging, surround view camera systems.
133. Active case work: 2Q2022 – Present; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Maxlite Inc.*, 19-CV-04047 (CA C.D. Filed 8th May 2019), (retained by defendant Maxlite Inc) – retained by defendant Procopio, Cory, Hargreaves and Savitch LLP.
   a. Deposition: 0 (Cumulative total: 58)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
134. Active case work: 1Q2022 – 4Q2022; *Advanced Engineering Services LLC., v. Lumasense Technologies Inc., and DOES* 1-50, 21-CV-03279-WHO combined with 20-CV-07905-WHO (CA N.D. Filed 23rd Feb 2022), (retained by plaintiff Advanced Engineering Services LLC) – retained by plaintiff SAC Attorneys LLP
   a. Deposition: 1 (Cumulative total: 59)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: Thermal, gas, and flow sensing for use in designing and manufacturing equipment used in semiconductor chip manufacturing. In particular, review of data relating to the simulation of finite element analysis ("FEA") and computational fluid dynamics ("CFD") data for gases, temperature, and stress with actual sensor data that could be intelligently integrated, customized, installed, tested, verified, and validated.
135. Active case work: 2Q2022-3Q2022; *Frontier Communications v. Charter Communications*, Pre-litigation IP and Due Diligence; Case No. TBD; Retained by Frontier Communications, (retained by Mayer Brown LLP)
   a. Deposition: 0 (Cumulative total: 59)

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   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: Optical PON for high-speed data FTTH evaluation, testing, and analysis.

136. Active case work: 2Q2022-3Q2022; *Russ, August & Kabat*, Pre-litigation IP and Due Diligence; Case No. TBD; (retained by plaintiff – Russ, August & Kabat LLP)
   a. Deposition: 0 (Cumulative total: 59)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: High volume fiber optic transceivers for EPON/GPON with: CDR circuits, 'Intelligence-in-the-Module' and 'M-ary' families.
137. Active case work: 2Q2022-3Q2022; *Signify Holding B.V. v. GE Lighting Solutions LLC.*, Declaration for IPR (IPR2022-XXX – in draft form for US patent #7,497,973) as petitioner, (retained by petitioner Signify Holding B.V.) – retained by Alston and Bird LLP
   a. Deposition: 0 (Cumulative total: 59)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: LED based light bulbs, LED chips that emit in the UV and visible, LED arrays, LED packaging including phosphors and encapsulants, and the type of phosphors utilized for different emission. In particular, phosphors that are activated by dopants such as Europium (Eu), Manganese (Mn) and the associated ions for these materials e.g. Mn2+, Mn3+, Mn4+, Mn6+, etc. Included analysis of InGaN and AlGaN based epitaxial material systems, and the use of phosphors in high pressure mercury vapor lamps.
138. Active case work: 3Q2022 – 2Q2023; *Canon, Inc., and Canon USA Inc v. WSOU Investments, LLC d/b/a Brazos Licensing and Development.*, Declaration for IPR ((IPR2022-01532) for US patent #7,493,030 as petitioner, (retained by Canon Inc) – retained by Orrick LLP
   a. Deposition: 0 (Cumulative total: 59)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: Digital camera operation including optical focus, image sensing, optical train, depth of field, exposure time, different focus and focal areas of a portion of the image, general photography and optical principles.
139. Active case work: 3Q2022 – 2Q2023; *Canon, Inc., and Canon USA Inc v. WSOU Investments, LLC d/b/a Brazos Licensing and Development.*, 21-CV- 00166-ADA-DTG (W.D. TX.) Filed 29th Sept 2022. (retained by defendant Canon Inc) – retained by Orrick LLP
   a. Deposition: 1 (Cumulative total: 60)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: Digital camera operation including optical focus, image sensing, optical train, depth of field, exposure time, different focus and focal areas of a portion of the image, general photography and optical principles.
140. Active case work: 3Q2022 – Present; *Fujifilm Sonosite., v. Butterfly Network, Inc.*, 1-22-CV-00309 (D. De) Filed 29th Mar 2022), (retained by defendant Butterfly Network, Inc.,) – retained by defendant Akin Gump LLP
   a. Deposition: 0 (Cumulative total: 60)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: Ultra-sonic equipment that includes displays, especially OLED displays. The electronic circuits and how displays are electronically controlled.
141. Active case work: 3Q2022 – Present; *LedComm LLC., v. IKEA US Retail LLC et al*, 6-22-CV-00302-ADA (W.D. Tx.) Filed 21st Mar 2022), (retained by defendant IKEA US Retail LLC et al.) – retained by defendant Flaster Greenberg LLP
   a. Deposition: 0 (Cumulative total: 60)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: LED surface mount packaging, LED GaN/InGaN chips, and associated LED lighting performance specifications.
142. Active case work: 2Q2022 – 3Q2022; *NXP Semiconductors N.V. and NXP USA Inc., v. MediaTek Inc, Amazon.com Inc., Belkin International Inc, Linksys USA Inc., et al*, ITC Investigation 337-TA-1287 entitled "Certain integrated circuits, and electronic devices and products containing the same" (Filed 1st Dec 2021), (retained by respondents Amazon.com Inc.,) – retained by respondent Morrison Foerster LLP
   a. Deposition: 0 (Cumulative total: 60)
   b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
   c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
   d. Technology: LED surface mount packaging, LED GaN/InGaN chips, and associated LED lighting performance specifications. LED Luminaires.

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143. Active case work: 3Q2022 – 4Q2022; *Amazon.com Inc., v. Epistar Corp.*, 6-22-CV-00526-ADA (W.D. Tx.) Filed 24th May 2022), (retained by defendant Amazon.com Inc..) – retained by defendant Morrison Foerster LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED surface mount packaging, LED GaN/InGaN chips, GaN/InGaN epitaxial growth, fabrication, device design and packaging. LED luminaires.
144. Active case work: 4Q2022 – 2Q2023; *Amazon.com Inc., v. Epistar Corp.*, 6-22-CV-00526-ADA (W.D. Tx.) Filed 24th May 2022), (retained by defendant Amazon.com Inc..) – retained by defendant Perkins Coie LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED surface mount packaging, LED GaN/InGaN chips, GaN/InGaN epitaxial growth, fabrication, device design and packaging. LED Luminaires.
145. Active case work: 4Q2022 – Present; *Qorvo., v. Akoustis Technologies Inc.*, 1-21-CV-1417-JPM (C.A.) Filed 4th Oct 2021), (retained by defendant Akoustis.) – retained by defendant Pillsbury LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: acoustic wave filters, BAW filters (bulk-acoustic-wave) filters for RF applications, devices, fabrication, and characterization
146. Active case work: 4Q2022 – 3Q2023; *LG Electronics Inc., v. TCL Electronics Holdings Ltd. (f/k/a TCL § Multimedia Technology Holdings, Ltd.); § TCL Industries Holdings Co., Ltd.; TCL § Industries Holdings (H.K.) Limited; TTE § Technology, Inc. (d/b/a TCL North § America); TTE Corporation; TCL Moka § International Limited; TCL Moka § Manufacturing S.A. de C.V.; TCL King § Electrical Appliances (Huizhou) Co. Ltd.; § Manufacturas Avanzadas S.A. de C.V.; § TCL Smart Device (Vietnam) Co., Ltd.; § Shenzhen TCL New Technology Co., Ltd.; § TCL Optoelectronics Technology (Huizhou) § Co., Ltd.; TCL Overseas Marketing Ltd.; § and TCL Technology Group Corporation § (f/k/a TCL Corp.), TCL Electronics Holdings Ltd et al.*, 2-22-CV-0122-JRG (W.D. Tx.) Filed 14th Oct 2022), (retained by plaintiff LGE) – retained by plaintiff counsel Baker Botts LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: BLU and backlighting of displays, especially LCD displays. Optical waveguide, reflecting, and transmission technology, optical sheet materials, optical shapes all utilizing LEDs in various optical package designs.
147. Active case work: 1Q2023 – 1Q2023; *NextGen Innovations, LLC v. Nokia of America Corporation et al.*, 2-22-CV-00309-JRG-RSP (E.D. Tex.), (filed: 9th Aug 2022), retained by plaintiff NextGen Innovations LLC., - retained by plaintiff counsel Russ August and Kabat LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Optical network systems, transceiver modules, passive optical networks, transceiver electronic and optoelectronic components and ICs.
148. Active case work: 1Q2023 – 1Q2023; *NextGen Innovations, LLC v. Infinera et al.*, 2-22-CV-00306-JRG-RSP (E.D. Tex.), (filed: 9th Aug 2022), retained by plaintiff NextGen Innovations LLC., - retained by plaintiff counsel Russ August and Kabat LLP.
    e. Deposition: 0 (Cumulative total: 60)
    f. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    g. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    h. Technology: Optical network systems, transceiver modules, passive optical networks, transceiver electronic and optoelectronic components and ICs.
149. Active case work: 3Q2023 – Present; *Ikea North America Services LLC., Ikea US Retail LLC., v. Everlight Electronics et al*, 2-23-CV-00126-ADA (E.D. Tx.) Filed 27th Mar 2023), (retained by defendant Ikea US Retail LLC et al.) – retained by defendant counsel Flaster Greenberg LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED surface mount packaging, LED GaN/InGaN chips, and associated LED lighting performance specifications.
150. Active case work: 1Q2023 – Present; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Current Lighting Solutions, LLC d/b/a GE Current.*, 6-22-CV-00534-ADA (W.D. Tx). Filed 16th Sep 2022), (retained by defendant GE Current) – retained by defendant counsel Norton Rose Fulbright US LLP.
    a. Deposition: 0 (Cumulative total: 60)

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b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.

151. Active case work: 1Q2023 – 2Q2023; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Current Lighting Solutions, LLC d/b/a GE Current.*, Declaration for IPR petition (IPR2023-00272) for US patent #10,830,397 as petitioner, (retained by Current Lighting) – retained by counsel Norton Rose Fulbright US LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
152. Active case work: 1Q2023 – 2Q2023; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Current Lighting Solutions, LLC d/b/a GE Current.*, Declaration for IPR petition (IPR2023-00984) for US patent #9,841,174 as petitioner, (retained by Current Lighting) – retained by counsel Norton Rose Fulbright US LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
153. Active case work: 1Q2023 – 2Q2023; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Current Lighting Solutions, LLC d/b/a GE Current.*, Declaration for IPR petition (IPR2023-00983) for US patent #10,487,991 as petitioner, (retained by Current Lighting) – retained by counsel Norton Rose Fulbright US LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
154. Active case work: 1Q2023 – 2Q2023; *Jiaxing Super Lighting Electric Appliance Co., LTD and Obert Inc. v. Current Lighting Solutions, LLC d/b/a GE Current.*, Declaration for IPR petition (IPR2023-00676) for US patent #9,939,140 as petitioner, (retained by Current Lighting) – retained by counsel Norton Rose Fulbright US LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED lighting and LED packaging technologies for T8 and T12 form factor tube lighting. Technologies such as LED luminaire/tube packaging, mechanical structure, thermal heat dissipation, electronic circuitry, printed circuit boards, and LED chips.
155. Active case work: 1Q2023 – Present; *US Conec. Ltd. v. Senko Advanced Components Inc.*, 1-23-CV-00083-UNA (D. De). Filed 24th Jan 2023), (retained by defendant US Conec Ltd.) – retained by defendant counsel Troutman Pepper Hamilton Sanders LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Fiber optic adapters, fiber optic connectors (simplex, duplex, quad, multi-fiber), fiber trays, racks, and fiber cabinet equipment. Single mode and multimode connector design, and fiber optic connector standards.
156. Active case work: 1Q2023 – 2Q2023; *US Conec. Ltd. v. Senko Advanced Components Inc.*, Declaration for IPR petition (IPR2023-00XXX) for US patent #11,307,369 as petitioner (retained by defendant US Conec Ltd.) – retained by defendant counsel Alston and Bird LLP (pending).
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Fiber optic adapters, fiber optic connectors (simplex, duplex, quad, multi-fiber), fiber trays, racks, and fiber cabinet equipment. Single mode and multimode connector design, and fiber optic connector standards.
157. Active case work: 1Q2023 – 2Q2023; *Inneos LLC., v. Opticis Co., Ltd.*, 8-23-CV-00185-JWH-ADS (C.D. Ca). Filed 30th Jan 2023), (retained by plaintiff GE Current) – retained by plaintiff counsel Womble Bond Dickinson (US) LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)

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c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
d. Technology: VCSEL transceiver WDM (wavelength division multiplexing) modules, package design, optics, freeform, diffractive, refractive, and optical filters. Multimode fiber optics designs.

158. Active case work: 1Q2023 – 1Q2023; *Viavi Solutions Inc., v Zhejiang Crystal-Optech Co. Ltd.*, 2-21-CV-0378-JRG (E.D. Tx) (filed: 3rd Aug 2022), retained by complainant Viavi Solutions Inc., – retained by counsel Venable, LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Optical filters and optical sensor systems, design and fabrication of dielectric materials for passband filters in applications such as optical communications, imaging, sensing, medical, automotive.
159. Active case work (pending): 1Q2023 – 2Q2023; *Signify North America Corporation and Signify Holding BV., v Satco Products Inc.*, 2-19-CV-06125-JMA-SIL (E.D. NY) (filed: 30th Oct 2022), retained by defendant Satco Products Inc., – retained by defendant counsel Pillsbury Winthrop Shaw Pittman, LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LED backlights, optical techniques for light distribution. Display panels, and LED packaging.
160. Active case work: 1Q2023 – 1Q2023; *Becton Dickinson and Company v. Beckman Coulter Inc.*, 1-21-CV-00833-CLC-JFH (D. De), (filed: 3rd Jan 2023), retained by plaintiff Becton Dickinson and Company, - retained by plaintiff counsel Quinn Emanuel Urquhart & Sullivan, LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Optical filters, sensors, micro-fluidics, lasers, optical test and measurement. Optical instrumentation for fluorescence analysis, characterization of fluorescent material.
161. Active case work: 2Q2023 – 2Q2023; *138 East LCD Advancements Limited v. Chongqing HKC Optoelectronics Technology Ltd.*, Declaration for IPR patent owner response (IPR2023-00476) for US patent #7,335,913 as patent owner, (retained by 138 East LCD Advancements Ltd.) – retained by counsel Robins Kaplan LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LCD display layouts, designs for optical and electronic fabrication, design, IC (drivers, electrical wiring, electrodes), and packaging.
162. Active case work: 2Q2023 – 2Q2023; *138 East LCD Advancements Limited v. Chongqing HKC Optoelectronics Technology Ltd.*, Declaration for IPR patent owner response (IPR2023-00475) for US patent #7,116,390 as patent owner, (retained by 138 East LCD Advancements Ltd.) – retained by counsel Robins Kaplan LLP
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: LCD display layouts, designs for optical and electronic fabrication, design, IC (drivers, electrical wiring, electrodes), and packaging.
163. Active case work: 2Q2023 – 3Q2023; *Samsung Display Company Limited v. Mianyang BOE Optoelectronics Technology Co., Ltd.*, ITC 337-TA-1351 (filed: 27th Jan 2023), "Certain Active Matrix Organic Light-Emitting Diode Display Panels And Modules For Mobile Devices, And Components Thereof", (retained by plaintiff Samsung Display Company Ltd.) – retained by counsel Covington and Burling LLP.
    a. Deposition: 0 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Active matrix OLED display panels and modules for mobile products and devices.
164. Active case work: 2Q2023 – Present; *Hesai Group, Hesai Technology Co., Ltd. and Hesai Inc. v. Ouster*, ITC 337-TA-1363 (filed: 11th May 2023), "Certain LiDAR (Light Detection And Ranging) Systems And Components Thereof", (retained by respondent Hesai et al.) – retained by counsel Quinn Emanuel Urquhart & Sullivan, LLP.
    a. Deposition: 1 (Cumulative total: 60)
    b. Trial/Hearing/Court appearance: 0 (Cumulative total: 19)
    c. IPR/PTAB trial/deposition: 0 (Cumulative total: 16)
    d. Technology: Optical and electrical device, optics, and package designs for LIDAR based self-driving vehicles. Rotating LIDAR unit, magnetic rotor/stator design, electronic pcbs, bulk, micro-optics, and optical and electronic system design.

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ISSUED utility PATENTS and PUBLISHED PATENT APPLICATIONS ISSUED:

Current combined total = 335

1	US-11614670-B2	Preview	PDF	Electro-optic polymer devices having high performance claddings, and methods of preparing the same	Yi; Youngwoo et al.	2023-03-28	21
2	US-11520175-B2	Preview	PDF	Active region-less modulator and method	Lebby; Michael et al.	2022-12-06	62
3	US-11506918-B2	Preview	PDF	Hybrid EO polymer modulator with ALD sealant layer	Lebby; Michael et al.	2022-11-22	18
4	US-11495670-B2	Preview	PDF	Integrated epitaxial metal electrodes	Pelzel; Rodney et al.	2022-11-08	25
5	US-11435603-B2	Preview	PDF	TFP optical transition device and method	Leonberger; Frederick J. et al.	2022-09-06	32
6	US-11435604-B2	Preview	PDF	Hybrid EO polymer modulator with silicon photonics	Lebby; Michael et al.	2022-09-06	21
7	US-20220246822-A1	Preview	PDF	Josephson Junction using Molecular Beam Epitaxy	Lebby; Michael S. et al.	2022-08-04	10
8	US-20220187638-A1	Preview	PDF	HYBRID EO POLYMER MODULATOR WITH ALD SEALANT LAYER	Lebby; Michael et al.	2022-06-16	18
9	US-20220187637-A1	Preview	PDF	HYBRID EO POLYMER MODULATOR WITH SILICON PHOTONICS	Lebby; Michael et al.	2022-06-16	22
10	US-20220113566-A1	Preview	PDF	TFP OPTICAL TRANSITION DEVICE AND METHOD	Leonberger; Frederick J. et al.	2022-04-14	32
11	US-11262605-B2	Preview	PDF	Active region-less polymer modulator integrated on a common PIC platform and method	Lebby; Michael et al.	2022-03-01	32

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12	US-20220052249-A1	Preview	PDF	A-axis Josephson Junctions with Improved Smoothness	Lebby; Michael S. et al.	2022-02-17	40
13	US-11201278-B2	Preview	PDF	Josephson Junction using molecular beam epitaxy	Lebby; Michael S. et al.	2021-12-14	10
14	US-11201451-B2	Preview	PDF	Porous distributed Bragg reflectors for laser applications	Hammond; Rich et al.	2021-12-14	20
15	US-11067748-B2	Preview	PDF	Guide transition device and method	Lebby; Michael et al.	2021-07-20	24
16	US-11063114-B2	Preview	PDF	III-N to rare earth transition in a semiconductor structure	Dargis; Rytis et al.	2021-07-13	23
17	US-11042051-B2	Preview	PDF	Direct drive region-less polymer modulator methods of fabricating and materials therefor	Lebby; Michael et al.	2021-06-22	25
18	US-20210141251-A1	Preview	PDF	ACTIVE REGION-LESS MODULATOR AND METHOD	Lebby; Michael et al.	2021-05-13	63
19	US-20210141250-A1	Preview	PDF	ACTIVE REGION-LESS MODULATOR AND METHOD	Lebby; Michael et al.	2021-05-13	29
20	US-10989871-B2	Preview	PDF	Protection layers for polymer modulators/waveguides	Becker; Richard et al.	2021-04-27	12
21	US-20210005720-A1	Preview	PDF	ELECTRONIC DEVICE WITH 2-DIMENSIONAL ELECTRON GAS BETWEEN POLAR-ORIENTED RARE-EARTH OXIDE LAYER GROWN OVER A SEMICONDUCTOR	Dargis; Rytis et al.	2021-01-07	23
22	US-10886694-B2	Preview	PDF	Hermetic capsule and method	Lebby; Michael	2021-01-05	17
23	US-10825912-B2	Preview	PDF	Integrated epitaxial metal electrodes	Pelzel; Rodney et al.	2020-11-03	20
24	US-20200285085-A1	Preview	PDF	DIRECT DRIVE REGION-LESS POLYMER MODULATOR METHODS OF FABRICATING AND MATERIALS THEREFOR	Lebby; Michael et al.	2020-09-10	25
25	US-10754093-B2	Preview	PDF	Fabrication process of polymer based photonic apparatus and the apparatus	Liu; Zhiming et al.	2020-08-25	12

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26	US-20200183201-A1	Preview	PDF	ACTIVE REGION-LESS POLYMER MODULATOR INTEGRATED ON A COMMON PIC PLATFORM AND METHOD	Lebby; Michael et al.	2020-06-11	31
27	US-20200183245-A1	Preview	PDF	ELECTRO-OPTIC POLYMER DEVICES HAVING HIGH PERFORMANCE CLADDINGS, AND METHODS OF PREPARING THE SAME	Yi; Youngwoo et al.	2020-06-11	21
28	US-20200161417-A1	Preview	PDF	III-N TO RARE EARTH TRANSITION IN A SEMICONDUCTOR STRUCTURE	Dargis; Rytis et al.	2020-05-21	20
29	US-20200150363-A1	Preview	PDF	CONDUCTIVE MULTI-FIBER/PORT HERMETIC CAPSULE AND METHOD	Lebby; Michael	2020-05-14	27
30	US-20200119516-A1	Preview	PDF	HERMETIC CAPSULE AND METHOD	Lebby; Michael	2020-04-16	16
31	US-10615141-B2	Preview	PDF	Pnictide buffer structures and devices for GaN base applications	Clark; Andrew et al.	2020-04-07	16
32	US-10605987-B2	Preview	PDF	Re-based integrated photonic and electronic layered structures	Clark; Andrew et al.	2020-03-31	42
33	US-20200091398-A1	Preview	PDF	JOSEPHSON JUNCTION USING MOLECULAR BEAM EPITAXY	Lebby; Michael S. et al.	2020-03-19	10
34	US-20200088939-A1	Preview	PDF	GUIDE TRANSITION DEVICE AND METHOD	Lebby; Michael et al.	2020-03-19	23
35	US-20200088941-A1	Preview	PDF	PROTECTION LAYERS FOR POLYMER MODULATORS/WAVEGUIDES	Becker; Richard et al.	2020-03-19	12
36	US-10591755-B2	Preview	PDF	Direct-drive polymer modulator methods of fabricating and materials therefor	Becker; Richard et al.	2020-03-17	20
37	US-20200083668-A1	Preview	PDF	GUIDE TRANSITION DEVICE WITH DIGITAL GRATING DEFLECTORS AND METHOD	Lebby; Michael et al.	2020-03-12	15
38	US-10573686-B2	Preview	PDF	Epitaxial AlN/cREO structure for RF filter applications	Wang; Wang Nang et al.	2020-02-25	19
39	US-10574025-B2	Preview	PDF	Hermetic capsule and method for a monolithic photonic integrated circuit	Lebby; Michael	2020-02-25	17

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40	US-10566944-B2	Preview	PDF	Layer structures for RF filters fabricated using rare earth oxides and epitaxial aluminum nitride	Pelzel; Rodney et al.	2020-02-18	28
41	US-10527786-B2	Preview	PDF	Polymer modulator and laser integrated on a common platform and method	Leonberger; Frederick J et al.	2020-01-07	27
42	US-10520673-B2	Preview	PDF	Protection layers for polymer modulators/waveguides	Becker; Richard et al.	2019-12-31	12
43	US-10509164-B2	Preview	PDF	Guide transition device and method	Lebby; Michael et al.	2019-12-17	23
44	US-10511146-B2	Preview	PDF	Guide transition device with digital grating deflectors and method	Lebby; Michael et al.	2019-12-17	16
45	US-20190353843-A1	Preview	PDF	FABRICATION PROCESS OF POLYMER BASED PHOTONIC APPARATUS AND THE APPARTUS	Liu; Zhiming et al.	2019-11-21	12
46	US-20190305039-A1	Preview	PDF	EPITAXIAL AIN/cREO STRUCTURE FOR RF FILTER APPLICATIONS	Wang; Wang Nang et al.	2019-10-03	18
47	US-10431729-B2	Preview	PDF	Josephson junction using molecular beam epitaxy	Lebby; Michael S. et al.	2019-10-01	10
48	US-20190278036-A1	Preview	PDF	EMBEDDED HERMETIC CAPSULE AND METHOD	Lebby; Michael	2019-09-12	22
49	US-20190237930-A1	Preview	PDF	HERMETIC CAPSULE AND METHOD	Lebby; Michael	2019-08-01	17
50	US-20190227233-A1	Preview	PDF	RE-based Integrated Photonic and Electronic Layered Structures	Clark; Andrew et al.	2019-07-25	41
51	US-20190221993-A1	Preview	PDF	POROUS DISTRIBUTED BRAGG REFLECTORS FOR LASER APPLICATIONS	Hammond; Rich et al.	2019-07-18	19
52	US-20190204506-A1	Preview	PDF	PROTECTION LAYERS FOR POLYMER MODULATORS/WAVEGUIDES	Becker; Richard et al.	2019-07-04	12
53	US-10332857-B2	Preview	PDF	Rare earth pnictides for strain management	Clark; Andrew et al.	2019-06-25	30
54	US-20190172923-A1	Preview	PDF	Integrated Epitaxial Metal Electrodes	Pelzel; Rodney et al.	2019-06-06	24

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55	US-20190148913-A1	Preview	PDF	GUIDE TRANSITION DEVICE WITH DIGITAL GRATING DEFLECTORS AND METHOD	Lebby; Michael et al.	2019-05-16	16
56	US-20190139761-A1	Preview	PDF	Pnictide Buffer Structures and Devices for GaN Base Applications	Clark; Andrew et al.	2019-05-09	15
57	US-20190122885-A1	Preview	PDF	GROUP III SEMICONDUCTOR EPITAXY FORMED ON SILICON VIA SINGLE CRYSTAL REN AND REO BUFFER LAYERS	Dargis; Rytis et al.	2019-04-25	13
58	US-20190079243-A1	Preview	PDF	GUIDE TRANSITION DEVICE AND METHOD	Lebby; Michael et al.	2019-03-14	24
59	US-20190074365-A1	Preview	PDF	Integrated Epitaxial Metal Electrodes	Pelzel; Rodney et al.	2019-03-07	20
60	US-20190064436-A1	Preview	PDF	POLYMER MODULATOR AND LASER INTEGRATED ON A COMMON PLATFORM AND METHOD	Leonberger; Frederick J et al.	2019-02-28	26
61	US-20190028081-A1	Preview	PDF	LAYER STRUCTURES FOR RF FILTERS FABRICATED USING RARE EARTH OXIDES AND EPITAXIAL ALUMINUM NITRIDE	Pelzel; Rodney et al.	2019-01-24	28
62	US-10162111-B1	Preview	PDF	Multi-fiber/port hermetic capsule sealed by metallization and method	Lebby; Michael	2018-12-25	34
63	US-10128350-B2	Preview	PDF	Integrated epitaxial metal electrodes	Pelzel; Rodney et al.	2018-11-13	20
64	US-20180259798-A1	Preview	PDF	DIRECT-DRIVE POLYMER MODULATOR METHODS OF FABRICATING AND MATERIALS THEREFOR	Becker; Richard et al.	2018-09-13	20
65	US-10075143-B2	Preview	PDF	Layer structures for RF filters fabricated using rare earth oxides and epitaxial aluminum nitride	Pelzel; Rodney et al.	2018-09-11	29
66	US-20180138284-A1	Preview	PDF	Integrated Epitaxial Metal Electrodes	Pelzel; Rodney et al.	2018-05-17	19
67	US-20180012858-A1	Preview	PDF	RARE EARTH INTERLAYS FOR MECHANICALLY LAYERING DISSIMILAR SEMICONDUCTOR WAFERS	Clark; Andrew et al.	2018-01-11	15
68	US-20180013053-A1	Preview	PDF	Josephson Junction using Molecular Beam Epitaxy	Lebby; Michael S. et al.	2018-01-11	10
69	US-20170353002-A1	Preview	PDF	Rare Earth Pnictides for Strain Management	Clark; Andrew et al.	2017-12-07	29
70	US-20170141750-A1	Preview	PDF	LAYER STRUCTURES FOR RF FILTERS FABRICATED USING RARE EARTH OXIDES AND EPITAXIAL ALUMINUM NITRIDE	Pelzel; Rodney et al.	2017-05-18	29
71	US-9496132-B2	Preview	PDF	Nucleation of III-N on REO templates	Arkun; Erdem et al.	2016-11-15	9
72	US-9443939-B2	Preview	PDF	Strain compensated REO buffer for III-N on silicon	Dargis; Rytis et al.	2016-09-13	7
73	US-20160133708-A1	Preview	PDF	STRAIN COMPENSATED REO BUFFER FOR III-N ON SILICON	Dargis; Rytis et al.	2016-05-12	7

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74	US-9236249-B2	Preview	PDF	III-N material grown on REN epitaxial buffer on Si substrate	Dargis; Rytis et al.	2016-01-12	9
75	US-9105471-B2	Preview	PDF	Rare earth oxy-nitride buffered III-N on silicon	Clark; Andrew et al.	2015-08-11	7
76	US-20150014676-A1	Preview	PDF	III-N MATERIAL GROWN ON REN EPITAXIAL BUFFER ON Si SUBSTRATE	Dargis; Rytis et al.	2015-01-15	10
77	US-20140357014-A1	Preview	PDF	HIGH EFFICIENCY SOLAR CELL USING IIIB MATERIAL TRANSITION LAYERS	LEBBY; MICHAEL et al.	2014-12-04	10
78	US-8889978-B2	Preview	PDF	III-V semiconductor interface with graded GeSn on silicon	Roucka; Radek et al.	2014-11-18	12
79	US-8878188-B2	Preview	PDF	REO gate dielectric for III-N device on Si substrate	Dargis; Rytis et al.	2014-11-04	8
80	US-8872308-B2	Preview	PDF	AlN cap grown on GaN/REO/silicon substrate structure	Arkun; Erdem et al.	2014-10-28	5
81	US-8835955-B2	Preview	PDF	IIIO.sub.xN.sub.y on single crystal SOI substrate and III n growth platform	Arkun; Erdem et al.	2014-09-16	10
82	US-8823055-B2	Preview	PDF	REO/ALO/A1N template for III-N material growth on silicon	Arkun; Erdem et al.	2014-09-02	7
83	US-8823025-B1	Preview	PDF	III-N material grown on AlO/AlN buffer on Si substrate	Arkun; Erdem et al.	2014-09-02	5
84	US-20140239307-A1	Preview	PDF	REO GATE DIELECTRIC FOR III-N DEVICE ON Si SUBSTRATE	DARGIS; RYTIS et al.	2014-08-28	8
85	US-20140231817-A1	Preview	PDF	III-N MATERIAL GROWN ON ALO/ALN BUFFER ON SI SUBSTRATE	Arkun; Erdem et al.	2014-08-21	5
86	US-20140231818-A1	Preview	PDF	AlN CAP GROWN ON GaN/REO/SILICON SUBSTRATE STRUCTURE	Arkun; Erdem et al.	2014-08-21	5
87	US-20140225123-A1	Preview	PDF	REO/ALO/AlN TEMPLATE FOR III-N MATERIAL GROWTH ON SILICON	Arkun; Erdem et al.	2014-08-14	10
88	US-8794010-B2	Preview	PDF	Laser cooling of modified SOI wafer	Williams; David L. et al.	2014-08-05	12
89	US-20140167057-A1	Preview	PDF	REO/ALO/AlN TEMPLATE FOR III-N MATERIAL GROWTH ON SILICON	Arkun; Erdem et al.	2014-06-19	7
90	US-8748900-B1	Preview	PDF	Re-silicide gate electrode for III-N device on Si substrate	Dargis; Rytis et al.	2014-06-10	10
91	US-8680507-B1	Preview	PDF	A1N inter-layers in III-N material grown on DBR/silicon substrate	Arkun; Erdem et al.	2014-03-25	6
92	US-20140076390-A1	Preview	PDF	III-V SEMICONDUCTOR INTERFACE WITH GRADED GeSn ON SILICON	Roucka; Radek et al.	2014-03-20	13

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93	US-20140077240-A1	Preview	PDF	IV MATERIAL PHOTONIC DEVICE ON DBR	Roucka; Radek et al.	2014-03-20	5
94	US-20140077338-A1	Preview	PDF	Si-Ge-Sn ON REO TEMPLATE	Roucka; Radek et al.	2014-03-20	5
95	US-20140077339-A1	Preview	PDF	DELTA DOPING AT Si-Ge INTERFACE	Roucka; Radek et al.	2014-03-20	5
96	US-20140053894-A1	Preview	PDF	GRADED GeSn ON SILICON	Roucka; Radek et al.	2014-02-27	13
97	US-8637763-B2	Preview	PDF	Solar cells with engineered spectral conversion	Lebby; Michael et al.	2014-01-28	18
98	US-8636844-B1	Preview	PDF	Oxygen engineered single-crystal REO template	Dargis; Rytis et al.	2014-01-28	10
99	US-8633569-B1	Preview	PDF	AlN inter-layers in III-N material grown on REO/silicon substrate	Arkun; Erdem et al.	2014-01-21	5
100	US-20140008644-A1	Preview	PDF	OXYGEN ENGINEERED SINGLE-CRYSTAL REO TEMPLATE	Dargis; Rytis et al.	2014-01-09	10
101	US-8623747-B1	Preview	PDF	Silicon, aluminum oxide, aluminum nitride template for optoelectronic and power devices	Arkun; Erdem et al.	2014-01-07	6
102	US-20130334536-A1	Preview	PDF	SINGLE-CRYSTAL REO BUFFER ON AMORPHOUS SiOx	Dargis; Rytis et al.	2013-12-19	7
103	US-8559097-B2	Preview	PDF	Integrated pump laser and rare earth waveguide amplifier	Williams; David L. et al.	2013-10-15	10
104	US-8553741-B2	Preview	PDF	Integrated rare earth devices	Lebby; Michael	2013-10-08	9
105	US-20130248853-A1	Preview	PDF	NUCLEATION OF III-N ON REO TEMPLATES	Arkun; Erdem et al.	2013-09-26	8
106	US-8542437-B1	Preview	PDF	Earth abundant photonic structures	Lebby; Michael S. et al.	2013-09-24	21
107	US-20130214282-A1	Preview	PDF	III-N ON SILICON USING NANO STRUCTURED INTERFACE LAYER	Arkun; Erdem et al.	2013-08-22	7
108	US-8501635-B1	Preview	PDF	Modification of REO by subsequent III-N EPI process	Clark; Andrew et al.	2013-08-06	10
109	US-20130153918-A1	Preview	PDF	REO-Si TEMPLATE WITH INTEGRATED REO LAYERS FOR LIGHT EMISSION	Clark; Andrew et al.	2013-06-20	9
110	US-8455756-B2	Preview	PDF	High efficiency solar cell using IIIB material transition layers	Lebby; Michael et al.	2013-06-04	10
111	US-20130099357-A1	Preview	PDF	STRAIN COMPENSATED REO BUFFER FOR III-N ON SILICON	Dargis; Rytis et al.	2013-04-25	7

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112	US-20130071960-A1	Preview	PDF	INTEGRATED RARE EARTH DEVICES	LEBBY; MICHAEL	2013-03-21	10
113	US-20130062609-A1	Preview	PDF	III-N FET ON SILICON USING FIELD SUPPRESSING REO	Smith; Robin et al.	2013-03-14	10
114	US-20130062610-A1	Preview	PDF	LATTICE MATCHED CRYSTALLINE REFLECTOR	Clark; Andrew et al.	2013-03-14	11
115	US-8394194-B1	Preview	PDF	Single crystal reo buffer on amorphous SiO.sub.x	Dargis; Rytis et al.	2013-03-12	7
116	US-20130032858-A1	Preview	PDF	RARE EARTH OXY-NITRIDE BUFFERED III-N ON SILICON	Clark; Andrew et al.	2013-02-07	8
117	US-8331410-B2	Preview	PDF	Spontaneous/stimulated light emitting .mu.-cavity device	Lebby; Michael et al.	2012-12-11	8
118	US-8331413-B2	Preview	PDF	Integrated rare earth devices	Lebby; Michael	2012-12-11	9
119	US-20120280276-A1	Preview	PDF	Single Crystal Ge On Si	Dargis; Rytis et al.	2012-11-08	6
120	US-20120256232-A1	Preview	PDF	Multilayer Rare Earth Device	Clark; Andrew et al.	2012-10-11	24
121	US-20120183767-A1	Preview	PDF	HEXAGONAL REO TEMPLATE BUFFER FOR III-N LAYERS ON SILICON	Dargis; Rytis et al.	2012-07-19	10
122	US-20120145243-A1	Preview	PDF	SOLAR CELLS WITH MAGNETICALLY ENHANCED UP-CONVERSION	Williams; David L. et al.	2012-06-14	13
123	US-20120147906-A1	Preview	PDF	LASER COOLING OF MODIFIED SOI WAFER	Williams; David L. et al.	2012-06-14	12
124	US-20120104443-A1	Preview	PDF	IIIOxNy ON SINGLE CRYSTAL SOI SUBSTRATE AND III n GROWTH PLATFORM	Clark; Andrew et al.	2012-05-03	9
125	US-20120104567-A1	Preview	PDF	IIIOxNy ON REO/Si	Clark; Andrew et al.	2012-05-03	6
126	US-20120090672-A1	Preview	PDF	REO-Ge Multi-Junction Solar Cell	LEBBY; MICHAEL S. et al.	2012-04-19	16
127	US-20120085399-A1	Preview	PDF	REO-Ge Multi-Junction Solar Cell	Lebby; Michael S. et al.	2012-04-12	17
128	US-20120073648-A1	Preview	PDF	Photovoltaic conversion using rare earths plus Group IV Sensitizers	Clark; Andrew et al.	2012-03-29	18
129	US-20120019902-A1	Preview	PDF	INTERGRATED PUMP LASER AND RARE EARTH WAVEGUIDE AMPLIFIER	Williams; David L. et al.	2012-01-26	10
130	US-20110290313-A1	Preview	PDF	SOLAR CELLS WITH ENGINEERED SPECTRAL CONVERSION	LEBBY; MICHAEL et al.	2011-12-01	19

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131	US-8049100-B2	Preview	PDF	Multijunction rare earth solar cell	Clark; Andrew et al.	2011-11-01	24
132	US-8039738-B2	Preview	PDF	Active rare earth tandem solar cell	Clark; Andrew et al.	2011-10-18	25
133	US-8039737-B2	Preview	PDF	Passive rare earth tandem solar cell	Clark; Andrew et al.	2011-10-18	17
134	US-20110220173-A1	Preview	PDF	ACTIVE SOLAR CONCENTRATOR WITH MULTI-JUNCTION DEVICES	LEBBY; MICHAEL	2011-09-15	15
135	US-20110203666-A1	Preview	PDF	HIGH EFFICIENCY SOLAR CELL USING IIIB MATERIAL TRANSITION LAYERS	Lebby; Michael et al.	2011-08-25	10
136	US-20110188533-A1	Preview	PDF	INTEGRATED RARE EARTH DEVICES	LEBBY; MICHAEL	2011-08-04	10
137	US-7968384-B2	Preview	PDF	Stacked transistors and process	Atanakovic; Petar B. et al.	2011-06-28	7
138	US-7967653-B2	Preview	PDF	Full color display	Lebby; Michael et al.	2011-06-28	11
139	US-20110108908-A1	Preview	PDF	MULTILAYERED BOX IN FDSOI MOSFETS	Lebby; Michael et al.	2011-05-12	34
140	US-7821066-B2	Preview	PDF	Multilayered BOX in FDSOI MOSFETS	Lebby; Michael et al.	2010-10-26	33
141	US-20100122720-A1	Preview	PDF	Passive Rare Earth Tandem Solar Cell	Clark; Andrew et al.	2010-05-20	17
142	US-20100116315-A1	Preview	PDF	Active rare earth tandem solar cell	Clark; Andrew et al.	2010-05-13	25
143	US-20100112736-A1	Preview	PDF	FULL COLOR DISPLAY	Lebby; Michael et al.	2010-05-06	12
144	US-20100109047-A1	Preview	PDF	Multijunction rare earth solar cell	Clark; Andrew et al.	2010-05-06	23
145	US-20100084680-A1	Preview	PDF	SPONTANEOUS/STIMULATED LIGHT EMITTING .mu.-CAVITY DEVICE	Lebby; Michael et al.	2010-04-08	8
146	US-7643526-B1	Preview	PDF	Spontaneous/stimulated light emitting .mu.-cavity device	Lebby; Michael et al.	2010-01-05	8
147	US-20090291535-A1	Preview	PDF	STACKED TRANSISTORS AND PROCESS	Atanackovic; Petar B. et al.	2009-11-26	7
148	US-7605531-B1	Preview	PDF	Full color display including LEDs with rare earth active areas and different radiative transistions	Lebby; Michael et al.	2009-10-20	11
149	US-7579623-B2	Preview	PDF	Stacked transistors and process	Atanackovic; Petar B. et al.	2009-08-25	7

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150	US-7538016-B2	Preview	PDF	Signal and/or ground planes with double buried insulator layers and fabrication process	Atanakovic; Petar B. et al.	2009-05-26	8
151	US-7388230-B1	Preview	PDF	Selective colored light emitting diode	Lebby; Michael et al.	2008-06-17	9
152	US-20080135924-A1	Preview	PDF	Multilayered box in FDSOI MOSFETS	Lebby; Michael et al.	2008-06-12	34
153	US-7365357-B2	Preview	PDF	Strain inducing multi-layer cap	Atanackovic; Petar B. et al.	2008-04-29	6
154	US-20080093670-A1	Preview	PDF	SIGNAL AND/OR GROUND PLANES WITH DOUBLE BURIED INSULATOR LAYERS AND FABRICATION PROCESS	Atanakovic; Petar B. et al.	2008-04-24	8
155	US-7355269-B1	Preview	PDF	IC on non-semiconductor substrate	Lebby; Michael et al.	2008-04-08	4
156	US-7323396-B2	Preview	PDF	Signal and/or ground planes with double buried insulator layers and fabrication process	Atanackovic; Petar B. et al.	2008-01-29	7
157	US-20070018166-A1	Preview	PDF	Stacked transistors and process	Atanackovic; Petar B. et al.	2007-01-25	8
158	US-20070018203-A1	Preview	PDF	Strain inducing multi-layer cap	Atanackovic; Petar B. et al.	2007-01-25	6
159	US-20060246691-A1	Preview	PDF	Signal and/or ground planes with double buried insulator layers and fabrication process	Atanackovic; Petar B. et al.	2006-11-02	8
160	US-6999644-B1	Preview	PDF	Discrete optoelectric package	Lebby; Michael S. et al.	2006-02-14	17
161	US-6966703-B1	Preview	PDF	Self eject latch mechanism for an optical transceiver module	Lebby; Michael S. et al.	2005-11-22	9
162	US-6795461-B1	Preview	PDF	Optoelectric module	Blair; Thomas H. et al.	2004-09-21	19
163	US-6663296-B1	Preview	PDF	Optoelectric module	Blair; Thomas H. et al.	2003-12-16	14

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164	US-6412989-B1	Preview	PDF	Directable laser transmission module	Hartman; Davis Howard et al.	2002-07-02	8
165	US-6243056-B1	Preview	PDF	Transceiver with miniature virtual image display	Jachimowicz; Karen E. et al.	2001-06-05	12
166	US-6228440-B1	Preview	PDF	Perishable media information storage mechanism and method of fabrication	Dailey; Conan B. et al.	2001-05-08	7
167	US-6158884-A	Preview	PDF	Integrated communicative watch	Lebby; Michael S. et al.	2000-12-12	9
168	US-6161106-A	Preview	PDF	Perishable media system and method of operation	Dailey; Conan B. et al.	2000-12-12	7
169	US-6156582-A	Preview	PDF	Method of fabricating top emitting ridge VCSEL with self-aligned contact and sidewall reflector	Shieh; Chan-Long et al.	2000-12-05	6
170	US-6131017-A	Preview	PDF	Dual system portable electronic communicator	Lebby; Michael S. et al.	2000-10-10	8
171	US-6122023-A	Preview	PDF	Non-speckle liquid crystal projection display	Chen; Diana et al.	2000-09-19	8
172	US-6121068-A	Preview	PDF	Long wavelength light emitting vertical cavity surface emitting laser and method of fabrication	Ramdani; Jamal et al.	2000-09-19	7
173	US-6115618-A	Preview	PDF	Portable electronic device with removable display	Lebby; Michael S. et al.	2000-09-05	6
174	US-6111839-A	Preview	PDF	Optical pickup head including a coherent first order mode laser light source	Milster; Tom D. et al.	2000-08-29	7
175	US-6096666-A	Preview	PDF	Holographic textile fiber	Jachimowicz; Karen E. et al.	2000-08-01	6
176	US-6097748-A	Preview	PDF	Vertical cavity surface emitting laser semiconductor chip with integrated drivers and photodetectors and method of fabrication	Huang; Rong-Ting et al.	2000-08-01	11
177	US-6097528-A	Preview	PDF	Microscanner for portable laser diode displays	Lebby; Michael S. et al.	2000-08-01	8

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178	US-6091754-A	Preview	PDF	VCSEL having integrated photodetector for automatic power control	Jiang; Wenbin et al.	2000-07-18	5
179	US-6084697-A	Preview	PDF	Integrated electro-optical package	Lebby; Michael S. et al.	2000-07-04	9
180	US-6080690-A	Preview	PDF	Textile fabric with integrated sensing device and clothing fabricated thereof	Lebby; Michael S. et al.	2000-06-27	8
181	US-6069593-A	Preview	PDF	Display carrier and electronic display control for multiple displays in a portable electronic device	Lebby; Michael S. et al.	2000-05-30	6
182	US-6064780-A	Preview	PDF	Interconnect substrate with a single contact accessible in an upper and an end surface	Blair; Thomas H. et al.	2000-05-16	6
183	US-6061380-A	Preview	PDF	Vertical cavity surface emitting laser with doped active region and method of fabrication	Jiang; Wenbin et al.	2000-05-09	8
184	US-6061485-A	Preview	PDF	Method for wavelength division multiplexing utilizing donut mode vertical cavity surface emitting lasers	Jiang; Wenbin et al.	2000-05-09	7
185	US-6029073-A	Preview	PDF	Display carrier with binocular viewing for a portable electronic device	Lebby; Michael S. et al.	2000-02-22	7
186	US-6026111-A	Preview	PDF	Vertical cavity surface emitting laser device having an extended cavity	Jiang; Wenbin et al.	2000-02-15	6
187	US-6022760-A	Preview	PDF	Integrated electro-optical package and method of fabrication	Lebby; Michael S. et al.	2000-02-08	12
188	US-6021146-A	Preview	PDF	Vertical cavity surface emitting laser for high power single mode operation and method of fabrication	Jiang; Wenbin et al.	2000-02-01	7
189	US-6021147-A	Preview	PDF	Vertical cavity surface emitting laser for high power single mode operation and method of fabrication	Jiang; Wenbin et al.	2000-02-01	7
190	US-6008067-A	Preview	PDF	Fabrication of visible wavelength vertical cavity surface emitting laser	Ramdani; Jamal et al.	1999-12-28	5
191	US-5978398-A	Preview	PDF	Long wavelength vertical cavity surface emitting laser	Ramdani; Jamal et al.	1999-11-02	5

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192	US-5974071-A	Preview	PDF	VCSEL with integrated photodetectors for automatic power control and signal detection in data storage	Jiang; Wenbin et al.	1999-10-26	8
193	US-5966399-A	Preview	PDF	Vertical cavity surface emitting laser with integrated diffractive lens and method of fabrication	Jiang; Wenbin et al.	1999-10-12	7
194	US-5959315-A	Preview	PDF	Semiconductor to optical link	Lebby; Michael S. et al.	1999-09-28	6
195	US-5956363-A	Preview	PDF	Long wavelength vertical cavity surface emitting laser with oxidation layers and method of fabrication	Lebby; Michael S. et al.	1999-09-21	7
196	US-5956364-A	Preview	PDF	Vertical cavity surface emitting laser with shaped cavity mirror and method of fabrication	Jiang; Wenbin et al.	1999-09-21	6
197	US-5953355-A	Preview	PDF	Semiconductor laser package with power monitoring system	Kiely; Philip et al.	1999-09-14	6
198	US-5946121-A	Preview	PDF	IrDA data link with VCSEL light source	Jiang; Wenbin et al.	1999-08-31	4
199	US-5943359-A	Preview	PDF	Long wavelength VCSEL	Ramdani; Jamal et al.	1999-08-24	5
200	US-5943357-A	Preview	PDF	Long wavelength vertical cavity surface emitting laser with photodetector for automatic power control and method of fabrication	Lebby; Michael S. et al.	1999-08-24	7
201	US-5939773-A	Preview	PDF	Semiconductor laser package including a lead frame and plastic resin housing	Jiang; Wenbin et al.	1999-08-17	8
202	US-5936929-A	Preview	PDF	Optical submodule and method for making	Jiang; Wenbin et al.	1999-08-10	7
203	US-5923696-A	Preview	PDF	Visible light emitting vertical cavity surface emitting laser with gallium phosphide contact layer and method of fabrication	Ramdani; Jamal et al.	1999-07-13	7
204	US-5914973-A	Preview	PDF	Vertical cavity surface emitting laser for high power operation and method of fabrication	Jiang; Wenbin et al.	1999-06-22	7
205	US-5906004-A	Preview	PDF	Textile fabric with integrated electrically conductive fibers and clothing fabricated thereof	Lebby; Michael S. et al.	1999-05-25	7
206	US-5905750-A	Preview	PDF	Semiconductor laser package and method of fabrication	Lebby; Michael S. et al.	1999-05-18	10
207	US-5903586-A	Preview	PDF	Long wavelength vertical cavity surface emitting laser	Ramdani; Jamal et al.	1999-05-11	5

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208	US-5898722-A	Preview	PDF	Dual wavelength monolithically integrated vertical cavity surface emitting lasers and method of fabrication	Ramdani; Jamal et al.	1999-04-27	8
209	US-5886972-A	Preview	PDF	Recording information in a phase change optical medium with a vertical cavity surface emitting laser	Jiang; Wenbin et al.	1999-03-23	5
210	US-5883912-A	Preview	PDF	Long wavelength VCSEL	Ramdani; Jamal et al.	1999-03-16	5
211	US-5881084-A	Preview	PDF	Semiconductor laser for package with power monitoring system	Huang; Rong-Ting et al.	1999-03-09	8
212	US-5848086-A	Preview	PDF	Electrically confined VCSEL	Lebby; Michael S. et al.	1998-12-08	7
213	US-5838703-A	Preview	PDF	Semiconductor laser package with power monitoring system and optical element	Lebby; Michael S. et al.	1998-11-17	9
214	US-5838707-A	Preview	PDF	Ultraviolet/visible light emitting vertical cavity surface emitting laser and method of fabrication	Ramdani; Jamal et al.	1998-11-17	8
215	US-5835521-A	Preview	PDF	Long wavelength light emitting vertical cavity surface emitting laser and method of fabrication	Ramdani; Jamal et al.	1998-11-10	7
216	US-5831960-A	Preview	PDF	Integrated vertical cavity surface emitting laser pair for high density data storage and method of fabrication	Jiang; Wenbin et al.	1998-11-03	7
217	US-5821571-A	Preview	PDF	Dual sided integrated electro-optical package	Lebby; Michael S. et al.	1998-10-13	13
218	US-5818404-A	Preview	PDF	Integrated electro-optical package	Lebby; Michael S. et al.	1998-10-06	18
219	US-5815524-A	Preview	PDF	VCSEL including GaTlP active region	Ramdani; Jamal et al.	1998-09-29	5
220	US-5796769-A	Preview	PDF	Red light vertical cavity surface emitting laser	Ramdani; Jamal et al.	1998-08-18	6
221	US-5789733-A	Preview	PDF	Smart card with contactless optical interface	Jachimowicz; Karen E. et al.	1998-08-04	7
222	US-5774486-A	Preview	PDF	Waveguide power monitoring system for vertical cavity surface emitting lasers	Jiang; Wenbin et al.	1998-06-30	6
223	US-5764671-A	Preview	PDF	VCSEL with selective oxide transition regions	Lebby; Michael S. et al.	1998-06-09	10
224	US-5757741-A	Preview	PDF	CD ROM head with VCSEL or VCSEL array	Jiang; Wenbin et al.	1998-05-26	11
225	US-5757829-A	Preview	PDF	Flip chip power monitoring system for vertical cavity surface emitting lasers	Jiang; Wenbin et al.	1998-05-26	6
226	US-5757836-A	Preview	PDF	Vertical cavity surface emitting laser with laterally integrated photodetector	Jiang; Wenbin et al.	1998-05-26	8

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227	US-5751757-A	Preview	PDF	VCSEL with integrated MSM photodetector	Jiang; Wenbin et al.	1998-05-12	5
228	US-5751471-A	Preview	PDF	Switchable lens and method of making	Chen; Diana et al.	1998-05-12	8
229	US-5748665-A	Preview	PDF	Visible VCSEL with hybrid mirrors	Jiang; Wenbin et al.	1998-05-05	7
230	US-5748161-A	Preview	PDF	Integrated electro-optical package with independent menu bar	Lebby; Michael S. et al.	1998-05-05	22
231	US-5742630-A	Preview	PDF	VCSEL with integrated pin diode	Jiang; Wenbin et al.	1998-04-21	6
232	US-5741724-A	Preview	PDF	Method of growing gallium nitride on a spinel substrate	Ramdani; Jamal et al.	1998-04-21	5
233	US-5739800-A	Preview	PDF	Integrated electro-optical package with LED display chip and substrate with drivers and central opening	Lebby; Michael S. et al.	1998-04-14	19
234	US-5732103-A	Preview	PDF	Long wavelength VCSEL	Ramdani; Jamal et al.	1998-03-24	5
235	US-5719892-A	Preview	PDF	Hybrid mirror structure for a visible emitting VCSEL	Jiang; Wenbin et al.	1998-02-17	8
236	US-5719893-A	Preview	PDF	Passivated vertical cavity surface emitting laser	Jiang; Wenbin et al.	1998-02-17	7
237	US-5710441-A	Preview	PDF	Microcavity LED with photon recycling	Ackley; Donald E. et al.	1998-01-20	5
238	US-5708280-A	Preview	PDF	Integrated electro-optical package and method of fabrication	Lebby; Michael S. et al.	1998-01-13	12
239	US-5706306-A	Preview	PDF	VCSEL with distributed Bragg reflectors for visible light	Jiang; Wenbin et al.	1998-01-06	6
240	US-5703664-A	Preview	PDF	Integrated electro-optic package for reflective spatial light modulators	Jachimowicz; Karen E. et al.	1997-12-30	13
241	US-5699073-A	Preview	PDF	Integrated electro-optical package with carrier ring and method of fabrication	Lebby; Michael S. et al.	1997-12-16	19
242	US-5661075-A	Preview	PDF	Method of making a VCSEL with passivation	Grodzinski; Piotr et al.	1997-08-26	9
243	US-5654228-A	Preview	PDF	VCSEL having a self-aligned heat sink and method of making	Shieh; Chan-Long et al.	1997-08-05	7
244	US-5644369-A	Preview	PDF	Switchable lens/diffuser	Jachimowicz; Karen E. et al.	1997-07-01	8
245	US-5638392-A	Preview	PDF	Short wavelength VCSEL	Ramdani; Jamal et al.	1997-06-10	6

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246	US-5636298-A	Preview	PDF	Coalescing optical module and method for making	Jiang; Wenbin et al.	1997-06-03	8
247	US-5633886-A	Preview	PDF	Short wavelength VCSEL with Al-free active region	Ramdani; Jamal et al.	1997-05-27	6
248	US-5625734-A	Preview	PDF	Optoelectronic interconnect device and method of making	Thomas; Ronald E. et al.	1997-04-29	7
249	US-5574744-A	Preview	PDF	Optical coupler	Gaw; Craig A. et al.	1996-11-12	7
250	US-5563900-A	Preview	PDF	Broad spectrum surface-emitting led	Ackley; Donald E. et al.	1996-10-08	7
251	US-5557626-A	Preview	PDF	Patterned mirror VCSEL with adjustable selective etch region	Grodzinski; Piotr et al.	1996-09-17	8
252	US-5555341-A	Preview	PDF	Waveguide with an electrically conductive channel	Sharma; Ravinder K. et al.	1996-09-10	7
253	US-5550941-A	Preview	PDF	Optoelectronic interface module	Lebby; Michael S. et al.	1996-08-27	8
254	US-5545359-A	Preview	PDF	Method of making a plastic molded optoelectronic interface	Ackley; Donald E. et al.	1996-08-13	9
255	US-5546413-A	Preview	PDF	Integrated light emitting device	Lebby; Michael S. et al.	1996-08-13	10
256	US-5543958-A	Preview	PDF	Integrated electro-optic package for reflective spatial light modulators	Lebby; Michael S. et al.	1996-08-06	14
257	US-5540799-A	Preview	PDF	Method of fabricating optical waveguide from a laminate	Lebby; Michael S. et al.	1996-07-30	6
258	US-5538919-A	Preview	PDF	Method of fabricating a semiconductor device with high heat conductivity	Lebby; Michael S. et al.	1996-07-23	8
259	US-5539200-A	Preview	PDF	Integrated optoelectronic substrate	Lebby; Michael S. et al.	1996-07-23	6
260	US-5539554-A	Preview	PDF	Integrated electro-optic package for reflective spatial light	Lebby; Michael S. et al.	1996-07-23	14
261	US-5534888-A	Preview	PDF	Electronic book	Lebby; Michael S. et al.	1996-07-09	8
262	US-5530715-A	Preview	PDF	Vertical cavity surface emitting laser having continuous grading	Shieh; Chan-Long et al.	1996-06-25	7
263	US-5521992-A	Preview	PDF	Molded optical interconnect	Chun; Christopher K. Y. et al.	1996-05-28	10
264	US-5517348-A	Preview	PDF	Voltage controlled transparent layer for a bi-directinal device	Lebby; Michael S.	1996-05-14	5

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265	US-5511138-A	Preview	PDF	Interlocking waveguide and method of making	Lebby; Michael S. et al.	1996-04-23	8
266	US-5498883-A	Preview	PDF	Superluminescent edge emitting device with apparent vertical light emission and method of making	Lebby; Michael S. et al.	1996-03-12	7
267	US-5493437-A	Preview	PDF	External communication link for a credit card pager	Lebby; Michael S. et al.	1996-02-20	10
268	US-5491491-A	Preview	PDF	Portable electronic equipment with binocular virtual display	Lebby; Michael S. et al.	1996-02-13	11
269	US-5486946-A	Preview	PDF	Integrated electro-optic package for reflective spatial light modulators	Jachimowicz; Karen E. et al.	1996-01-23	14
270	US-5485318-A	Preview	PDF	Dual image manifestation apparatus with integrated electro-optical package	Lebby; Michael S. et al.	1996-01-16	17
271	US-5482658-A	Preview	PDF	Method of making an optoelectronic interface module	Lebby; Michael S. et al.	1996-01-09	8
272	US-5482891-A	Preview	PDF	VCSEL with an intergrated heat sink and method of making	Shieh; Chan-Long et al.	1996-01-09	6
273	US-5478774-A	Preview	PDF	Method of fabricating patterned-mirror VCSELs using selective growth	Ackley; Donald E. et al.	1995-12-26	7
274	US-5473716-A	Preview	PDF	Fiber bundle interconnect and method of making same	Lebby; Michael S. et al.	1995-12-05	8
275	US-5468656-A	Preview	PDF	Method of making a VCSEL	Shieh; Chan-Long et al.	1995-11-21	9
276	US-5469185-A	Preview	PDF	Remote sensory unit and driver	Lebby; Michael S. et al.	1995-11-21	7
277	US-5468582-A	Preview	PDF	Fused optical layer and method of making	Blair; Thomas H. et al.	1995-11-21	7
278	US-5466633-A	Preview	PDF	Optical reading head and method for making same	Ackley; Donald E. et al.	1995-11-14	11
279	US-5467215-A	Preview	PDF	Integrated electro-optic package for reflective spatial light modulators	Lebby; Michael S. et al.	1995-11-14	13
280	US-5452387-A	Preview	PDF	Coaxial optoelectronic mount and method of making same	Chun; Christopher K. Y. et al.	1995-09-19	5
281	US-5446752-A	Preview	PDF	VCSEL with current blocking layer offset	Ackley; Donald E. et al.	1995-08-29	10
282	US-5437092-A	Preview	PDF	Method of making contact areas on an optical waveguide	Hartman; Davis H. et al.	1995-08-01	7
283	US-5432809-A	Preview	PDF	VCSEL with Al-free cavity region	Grodzinski; Piotr et al.	1995-07-11	7

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284	US-5432630-A	Preview	PDF	Optical bus with optical transceiver modules and method of manufacture	Lebby; Michael S. et al.	1995-07-11	16
285	US-5428704-A	Preview	PDF	Optoelectronic interface and method of making	Lebby; Michael S. et al.	1995-06-27	16
286	US-5422901-A	Preview	PDF	Semiconductor device with high heat conductivity	Lebby; Michael S. et al.	1995-06-06	7
287	US-5416870-A	Preview	PDF	Optoelectronic interface device and method with reflective surface	Chun; Christopher K. Y. et al.	1995-05-16	8
288	US-5408547-A	Preview	PDF	Optical read/write head	Lebby; Michael S. et al.	1995-04-18	10
289	US-5400423-A	Preview	PDF	Molded star coupler and method of making same	Chun; Christopher K. Y. et al.	1995-03-21	5
290	US-5400352-A	Preview	PDF	Semiconductor laser and method therefor	Lebby; Michael S. et al.	1995-03-21	5
291	US-5389312-A	Preview	PDF	Method of fabricating molded optical waveguides	Lebby; Michael S. et al.	1995-02-14	8
292	US-5390275-A	Preview	PDF	Molded waveguide and method for making same	Lebby; Michael S. et al.	1995-02-14	9
293	US-5388120-A	Preview	PDF	VCSEL with unstable resonator	Ackley; Donald E. et al.	1995-02-07	5
294	US-5369529-A	Preview	PDF	Reflective optoelectronic interface device and method of making	Kuo; Shun-Meen et al.	1994-11-29	7
295	US-5369415-A	Preview	PDF	Direct retinal scan display with planar imager	Richard; Fred V. et al.	1994-11-29	6
296	US-5367593-A	Preview	PDF	Optical/electrical connector and method of fabrication	Lebby; Michael S. et al.	1994-11-22	10
297	US-5361317-A	Preview	PDF	Assembly with fixture aligning and affixing an optical fiber to an optical device	Hartman; Davis H. et al.	1994-11-01	7
298	US-5359686-A	Preview	PDF	Interface for coupling optical fibers to electronic circuitry	Galloway; David et al.	1994-10-25	17
299	US-5358880-A	Preview	PDF	Method of manufacturing closed cavity LED	Lebby; Michael S. et al.	1994-10-25	6
300	US-5359618-A	Preview	PDF	High efficiency VCSEL and method of fabrication	Lebby; Michael S. et al.	1994-10-25	6
301	US-5359669-A	Preview	PDF	Remote retinal scan identifier	Shanley; Charles W. et al.	1994-10-25	7
302	US-5351257-A	Preview	PDF	VCSEL with vertical offset operating region providing a lateral waveguide and current limiting and method of fabrication	Lebby; Michael S. et al.	1994-09-27	10

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303	US-5351331-A	Preview	PDF	Method and apparatus for splicing optical fibers with signal I/O	Chun; Christopher K. Y. et al.	1994-09-27	11
304	US-5349210-A	Preview	PDF	Optical reading head with angled array	Ackley; Donald E. et al.	1994-09-20	10
305	US-5348616-A	Preview	PDF	Method for patterning a mold	Hartman; Davis H. et al.	1994-09-20	12
306	US-5345524-A	Preview	PDF	Optoelectronic transceiver sub-module and method for making	Lebby; Michael S. et al.	1994-09-06	9
307	US-5345527-A	Preview	PDF	Intelligent opto-bus with display	Lebby; Michael S. et al.	1994-09-06	11
308	US-5345530-A	Preview	PDF	Molded waveguide and method for making same	Lebby; Michael S. et al.	1994-09-06	8
309	US-5337391-A	Preview	PDF	Optoelectronic sub-module and method of making same	Lebby; Michael S.	1994-08-09	10
310	US-5337397-A	Preview	PDF	Optical coupling device and method for making	Lebby; Michael S. et al.	1994-08-09	7
311	US-5335300-A	Preview	PDF	Method of manufacturing I/O node in an optical channel waveguide and apparatus for utilizing	Hartman; Davis H. et al.	1994-08-02	10
312	US-5325451-A	Preview	PDF	Modular optical waveguide and method for making	Hartman; Davis et al.	1994-06-28	5
313	US-5324964-A	Preview	PDF	Superluminescent surface light emitting device	Ackley; Donald E. et al.	1994-06-28	5
314	US-5323477-A	Preview	PDF	Contact array imager with integral waveguide and electronics	Lebby; Michael S. et al.	1994-06-21	10
315	US-5313545-A	Preview	PDF	Molded waveguide with a unitary cladding region and method of making	Kuo; Shun-Meen et al.	1994-05-17	11
316	US-5309537-A	Preview	PDF	Optoelectronic coupling device and method of making	Chun; Christopher K. Y. et al.	1994-05-03	11
317	US-5286982-A	Preview	PDF	High contrast ratio optical modulator	Ackley; Donald E. et al.	1994-02-15	7
318	US-5282071-A	Preview	PDF	Contact areas on an optical waveguide and method of making	Hartman; Davis H. et al.	1994-01-25	8
319	US-5276762-A	Preview	PDF	Magnetic holding methods for optical fiber I/O assembly	Hartman; Davis H. et al.	1994-01-04	4
320	US-5276754-A	Preview	PDF	Optoelectronic mount and method for making	Blair; Thomas H. et al.	1994-01-04	7
321	US-5271083-A	Preview	PDF	Molded optical waveguide with contacts utilizing leadframes and method of making same	Lebby; Michael S. et al.	1993-12-14	10
322	US-5265184-A	Preview	PDF	Molded waveguide and method for making same	Lebby; Michael S. et al.	1993-11-23	8
323	US-5249245-A	Preview	PDF	Optoelectroinc mount including flexible substrate and method for making same	Lebby; Michael S. et al.	1993-09-28	10

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324	US-5230030-A	Preview	PDF	Interface coupling electronic circuitry	Hartman; Davis H. et al.	1993-07-20	6
325	US-5228101-A	Preview	PDF	Electrical to optical links using metalization	Lebby; Michael S. et al.	1993-07-13	6
326	US-5225816-A	Preview	PDF	Electrical connector with display	Lebby; Michael S. et al.	1993-07-06	4
327	US-5218465-A	Preview	PDF	Intelligent interconnects for broadband optical networking	Lebby; Michael S. et al.	1993-06-08	6
328	US-5172384-A	Preview	PDF	Low threshold current laser	Goronkin; Herbert et al.	1992-12-15	14
329	US-5170448-A	Preview	PDF	Optical waveguide apparatus and method for partially collecting light	Ackley; Donald E. et al.	1992-12-08	7
330	US-5125054-A	Preview	PDF	Laminated polymer optical waveguide interface and method of making same	Ackley; Donald E. et al.	1992-06-23	6
331	US-5116461-A	Preview	PDF	Method for fabricating an angled diffraction grating	Lebby; Michael S. et al.	1992-05-26	5
332	US-5067829-A	Preview	PDF	Dynamic optical beam steering	Jaskie; James E. et al.	1991-11-26	7
333	US-5068007-A	Preview	PDF	Etching of materials in a noncorrosive environment	Rogers; Stephen P. et al.	1991-11-26	6
334	US-5045908-A	Preview	PDF	Vertically and laterally illuminated p-i-n photodiode	Lebby; Michael S.	1991-09-03	5
335	US-5034092-A	Preview	PDF	Plasma etching of semiconductor substrates	Lebby; Michael S. et al.	1991-07-23	5

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56. G. W. Taylor, **M. S. Lebby**, T. Y. Chang, R. P. Gnall, N. Sauer, B. Tell, and J. G. Simmons, " Very High Transconductance HFET", *IEEE International Electron Devices Conference and Proceedings*, LA, Dec 1988.
57. Crawford, D.L.; Taylor, G.W.; Kiely, P.A.; Cooke, P.; Izabelle, A.; Chang, T.Y.; Tell, B.; **Lebby, M.S**.; Brown-Goebeler, K.; Simmons, J.G., "An inversion channel technology for opto-electronic integration," Fourteenth European Conference on Optical Communication, No. 292, vol. 1, pp. 211-14, Sept. 1988.
58. Taylor, G.W.; **Lebby, M.S**.; Kiely, P.A.; Cooke, P.; Isabelle, A.; Chang, T.Y.; Tell, B.; Crawford, D.L.; Brown-Goebeler, K.; Simmons, J.G., "Performance and advantages of BICFETs versus HBTs," Proceedings of the 1988 Bipolar Circuits and Technology Meeting, pp. 41-5, Sept. 1988.
59. Taylor, G.W.; Crawford, D.L.; Kiely, P.A.; Sargood, S.K.; Cooke, P.; Izabelle, A.; Chang, T.Y.; Tell, B.; **Lebby, M.S**.; Brown-Goebeler, K.; Simmons, J.G.,

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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"GaAs/AlGaAs inversion channel devices for an integrated opto-electronic technology," IEEE Transactions on Electron Devices, vol. 35, no. 12, pp. 2446, June 1988.

60. **Lebby, M.S.**; Taylor, G.W.; Izabelle, A.; Tell, B.; Brown-Goebeler, K.; Chang, T.-Y.; Simmons, J.G., "A p-channel BICFET in the InGaAs/InAlAs material system," IEEE Electron Device Letters, vol. 9 , no. 6 , pp. 278-80, June 1988.
61. Taylor, G.W.; **Lebby, M.S.**; Izabelle, A.; Tell, B.; Brown-Goebeler, K.; Chang, T.-Y.; Simmons, J.G., "Demonstration of a p-channel GaAs/AlGaAs BICFET," IEEE Electron Device Letters, vol. 9, no.2, pp.84-6, Feb. 1988.
62. Taylor, Geoffrey; **Lebby, M S**; Izabelle, A; Tell, B; Brown-Goebeler, K., "Demonstration of a p-channel GaAs/AlGaAs BICFET (Bipolar Inversion- Channel)," IEEE Electron Device Letters, vol. 9, pp. 84-86, Feb. 1988.
63. **Lebby, Michael Stephen**, "Fabrication And Characterisation Of The Heterojunction Field Effect Transistor (Hfet) And The Bipolar Inversion Channel Field Effect Transistor (Bicfet): Characterisation Of Hfets And Bicfets, Fabricated From Gallium-Arsenide/Aluminum-Gallium - Arsenide With Magnetron Ion Etching, Sputtered Tungsten Gates, Ion Implanted Source/Drain Contacts And Rapid Thermal Anneals," University Of Bradford, UK, 1987.
64. Taylor, G.W.; **Lebby, M.S.**; Chang, T.Y.; Gnall, R.N.; Sauer, N.; Tell, B.; Simmons, J.G., "GaAs/AlGaAs inversion channel devices for an integrated opto-electronic technology," Electronics Letters, vol. 23, no. 2, pp. 77-9, Jan. 1987.
65. Taylor, G.W.; **Lebby, M.S.**; Chang, T.Y.; Gnall, R.N.; Sauer, N.; Tell, B.; Tennant, D.M.; Simmons, J.G., "A new heterostructure FET," International Electron Devices Meeting 1986. Technical Digest, pp. 817-21, Dec. 1986.

PUBLIC MEDIA (Books, Chapters, Reports, Abstracts, Videos, Lectures, Speeches, Reviews, Courses, Talks, Invited Talks, Keynote Talks, Plenary Talks, Webinars, Interviews, Articles, etc.)

1986

1) Paper: A new heterostructure FET
    a. Dec 1986
    b. "Electron Devices Meeting, 1986 International Volume: 32 Digital Object Identifier: 10.1109/IEDM.1986.191323 Publication Year: 1986, Page(s): 817-821"

1987

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
1 Hawthorne St., unit 25a, San Francisco, CA 94105, USA; mobile +1 717 839 7078; drmlebby@gmail.com

2) Thesis: Fabrication and characterization of the heterojunction field effect transistor and the bipolar inversion channel field effect transistor
    a. 1987
    b. Characterization of HFETs and BICFETs fabricated from GaAs/AlGaAs with magnetron ion etching, sputtered tungsten gates, ion implanted source/drain contacts and rapid thermal anneals.
    c. University of Bradford, UK 1987
    d. http://www.edt.brad.ac.uk/home/
3) http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1486581Paper: Very high-transconductance heterojunction field-effect transistor (HFET)
    a. Jan 1987
    b. "A new form of FET has been demonstrated in the GaAs/AlGaAs material system. Designated the HFET, it has shown a transconductance of 500mS/mm at 300 K for a nominal Lg = 2/un and a drain current of 430mA/mm. The conduction occurs in an inversion channel at the heterointerface"
    c. "Electronics Letters Volume: 23, Issue: 2 Digital Object Identifier: 10.1049/el:19870056 Publication Year: 1987 , Page(s): 77 - 79"
    d. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4257306
4) Talk and abstract: Magnetron Ion Etching of self aligned HFETs
    a. May 1987
    b. Electrochemical Society (ECS) Conference proceedings SOTAPOCS VI, Compound Semiconductors, Philadelphia
    c. http://www.electrochem.org/meetings/biannual/past_meetings_list.htm

1988

5) Paper: Demonstration of a p-channel GaAs/AlGaAs BICFET
    a. Feb 1988
    b. "Electron Device Letters, IEEE Volume: 9, Issue: 2 Digital Object Identifier: 10.1109/55.2048 Publication Year: 1988 , Page(s): 84 - 86"
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=2048
6) Paper: GaAs/AlGaAs inversion channel devices for an integrated opto-electronic technology
    a. Jun 1988
    b. "Electron Devices, IEEE Transactions on Volume: 35, Issue: 12 Digital Object Identifier: 10.1109/16.8871 Publication Year: 1988"
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8871
7) Paper: A p-channel BICFET in the InGaAs/InAlAs material system
    a. Jun 1988

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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   b. "Electron Device Letters, IEEE Volume: 9, Issue: 6 Digital Object Identifier: 10.1109/55.716 Publication Year: 1988 , Page(s): 278 - 280"
   c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=716&tag=1
8) Paper: An inversion channel technology for opto-electronic integration
   a. Sep 1988
   b. "Optical Communication, 1988. (ECOC 88). Fourteenth European Conference on (Conf. Publ. No.292), Publication Year: 1988, Page(s): 211 - 214 vol.1"
9) http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=93560 Paper: Performance and advantages of BICFETs versus HBTs
   a. Sep 1988
   b. "Bipolar Circuits and Technology Meeting, 1988., Proceedings of the 1988 Digital Object Identifier: 10.1109/BIPOL.1988.51041 Publication Year: 1988 , Page(s): 41- 45"
   c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=51041
10) Talk and abstract: RIE and MIE comparison for optoelectronic integrated circuit processing
   a. Nov 1988
   b. IEEE LEOS Conference, Santa Clara, California
11) Paper: Reactive ion etching (RIE) and magnetron ion etching (MIE) combinations for opto-electronic integrated circuit (OEIC) processing
   a. Nov 1988
   b. Proc. SPIE Vol. 1037, p. 88, Monitoring and Control of Plasma-Enhanced Processing of Semiconductors, James E. Griffiths; Ed.
   c. http://spie.org/x648.html?product_id=951018

1989

1) Paper: An n-channel BICFET in the InGaAs/InAlGaAs/InAlAs material system
   a. 1989
   b. "Electron Device Letters, IEEE Volume: 10 , Issue: 7 Digital Object Identifier: 10.1109/55.29660 Publication Year: 1989 , Page(s): 304 - 306"
   c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=29660&tag=1
2) Paper: An n-channel BICFET in the GaAs/AlGaAs material system
   a. Feb 1989
   b. "Electron Device Letters, IEEE Volume: 10, Issue: 2 Digital Object Identifier: 10.1109/55.32438 Publication Year: 1989 , Page(s): 88 - 90"
   c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=32438&tag=1
3) Paper: An Inversion Channel Technology For Opto-Electronic Integration
   a. 8th Feb 1989

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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b. A new approach to optoelectronic integration is reported which combines electronic and optical devices fabricated with a common sequence and a single MBE wafer growth. The devices have in common, an inversion layer structure produced by charge sheet doping.
c. Proceedings Vol. 0994 Optoelectronic Materials, Devices, Packaging, and Interconnects II, Glen M. McWright; Henry J. Wojtunik, Editors, pp.251-510 Date: 9 February 1989 ISBN: 9780819400291
d. http://spie.org/x648.html?product_id=960136

1991

4) Invited talk and abstract: Use of VCSELs for the MONSOON parallel digital computer
   a. Jan 1991
   b. International workshop on architectures for free-space digital computing, Colorado.
5) Invited Paper and Presentation: Approaching the problem of high-density interconnects in the 'Monsoon' data-flow parallel processor with optics"
   a. 28th Jan1991
   b. AFOSR, ONR, DARPA: A compendium of position papers from the workshop on architectures for free space digital optical computing
   c. http://www.researchgate.net/publication/235184814_A_Compendium_of_Position_Papers_from_the_Workshop_on_Architectures_for_Free_Space_Digital_Optical_Computing_Held_in_Vail_Colorado_on_28-30_January_1991

1993

6) Invited talk and abstract: Optoelectronic Devices and Applications
   a. 1993
   b. IEEE workshop on optical interconnects
7) Invited talk and abstract: VCSEL Technology and Progress
   a. 1993
   b. IEEE Waves and Devices, Phoenix Section, Tempe, Arizona, Arizona State University

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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1994

8) Invited talk and abstract: Ridge waveguide VCSELs: improvement over planar VCSELs
    a. May 1994
    b. USA Laser workshop, CLEO, Baltimore, MD
9) Invited talk and abstract: Packaging VCSELs with GUIDECAST(tm) an overmolded waveguide packaging platform
    a. Aug 1994
    b. IEEE Tropical workshop on optoelectronic packaging, Breckenridge, Colorado.

1995

10) Paper: Parallel optical interconnects using VCSELs
    a. 1995
    b. "High Speed Semiconductor Devices and Circuits, 1995. Proceedings., IEEE/Cornell Conference on Advanced Concepts in Digital Object Identifier: 10.1109/CORNEL.1995.482526 Publication Year: 1995 , Page(s): 348 - 356"
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=482526
11) Book: Research in VCSEL devices - Annual technical review1995
    a. 1995
    b. Annual collection of optoelectronic device and reliability department papers at the photonics technology center, Motorola, Tempe, USA.
    c. Key focus was the commercialization of VCSEL technology, especially at 850nm for the Optobus™ parallel array product and other associated VCSEL prototypes.
    d. Motorola
12) Invited talk and abstract: Ridge waveguide VCSEL device performance
    a. May 1995
    b. USA Laser workshop, CLEO, Anaheim, California
13) Invited talk and abstract: VCSEL Arrays and GUIDECAST(tm) packaging technology as used in OPTOBUS(tm)
    a. Sep 1995
    b. European Laser Workshop, Eindhoven, Netherlands

1996

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
1 Hawthorne St., unit 25a, San Francisco, CA 94105, USA; mobile +1 717 839 7078; drmlebby@gmail.com

14) Book: Research in optoelectronic devices volume II
    a. 1996
    b. Annual collection of optoelectronic device and reliability department papers at the photonics technology center, Motorola, Tempe, USA. Key focus was the commercialization of VCSEL technology, especially at 850nm for the optobus parallel array product and other associated VCSEL prototypes. Demonstration of 660nm VCSELs discussed.
    c. Motorola
15) Paper: Low-cost high-performance optical interconnect
    a. 1996
    b. Proceedings, Conference on Lasers and Electro-Optics, (CLEO), vol 9, 1996
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=864750
16) Paper: Key challenges and results of VCSELs in data links
    a. 1996
    b. "Lasers and Electro-Optics Society Annual Meeting, 1996. LEOS 96., IEEE Volume: 2 Digital Object Identifier: 10.1109/LEOS.1996.571604 Publication Year: 1996 , Page(s): 167 - 168 vol.2"
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=571604
17) Paper: A low-cost high-performance optical interconnect
    a. 1996
    b. "Components, Packaging, and Manufacturing Technology, Part B: Advanced Packaging, IEEE Transactions on Volume: 19 , Issue: 3 Digital Object Identifier: 10.1109/96.533892 Publication Year: 1996 , Page(s): 532- 539"
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=533892
18) Paper: Characteristics of VCSEL arrays for parallel optical interconnects
    a. 1996
    b. "Electronic Components and Technology Conference, 1996. Proceedings., 46th Digital Object Identifier: 10.1109/ECTC.1996.517404 Publication Year: 1996 , Page(s): 279 - 291"
    c. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=517404
19) Paper: Use of VCSEL arrays for parallel optical interconnects
    a. 10th Apr 1996
    b. Proc. SPIE 2683, Fabrication, Testing, and Reliability of Semiconductor Lasers, 81 (April 10, 1996); doi:10.1117/12.237679
    c. http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1015866
20) Paper: A low-cost high-performance optical interconnect
    a. Aug 1996
    b. The Optobus™ link is a ten channel parallel bidirectional data link based on multimode fiber ribbons. The guiding principal of the Optobus™ design was to produce an optical interconnect capable of competing with copper on price, not just performance. Recognizing that packaging dominates the cost of optical

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interconnects, the design focused on minimizing the complexity of the optical subassembly. A key component of this strategy is the use of AlGaAs/GaAs vertical cavity surface emitting lasers (VCSELs). Another is designing the silicon receiver and transmitter arrays around the module level packaging parasitics. The resulting parallel transceiver modules achieve a minimum throughput of 1.5 Gb/s in each direction with a power dissipation of 1.6 W

   c. Components, Packaging, and Manufacturing Technology, Part B: Advanced Packaging, IEEE Transactions on Volume: 19 , Issue: 3 Page(s): 532 - 539
   d. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=533892

21) Invited talk and abstract: Ridge Waveguide and Planar VCSEL Device Reliability
   a. Sep 1996
   b. European Laser Workshop, Olso, Norway
22) Invited talk and abstract: Vertical cavity surface emitting lasers for communication applications
   a. Oct 1996
   b. Optical Society of America (OSA) Annual meetings, proceedings, paper WR1, Rochester, NY
23) Paper: Characteristics of VCSELs and VCSEL arrays for Optical Data Links
   a. 10th Dec 1996
   b. Motorola: Technical Enrichment Matrix Conference, Motorola SPS - SABA, Hilton Pavilion, Mesa, Az

1997

24) Paper: Effect of proton implantation on the degradation of GaAs/AlGaAs vertical cavity surface emitting lasers
   a. 1997
   b. Electronics Letters, ISSN 0013-5194, 1997, Volume 33, Issue 2, p. 137
   c. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=579434
25) Paper (invited): Laser safety issues with VCSEL arrays in OPTOBUS(tm)
   a. 1997
   b. Optical Society of America (OSA); Annual Meeting, Micro-optics session
26) Paper: Relative intensity noise of 780nm vertical cavity surface emitting lasers Jan 1997
   a. Proceedings of the 1997 Pacific Rim Conference on Lasers and Electro-Optics, CLEO/Pacific Rim, No 46984, Jan 1997
   b. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=610586
27) Paper: Characteristics of VCSELs and VCSEL arrays for optical data links
   a. Feb 1997

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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   b. Proc. SPIE 3004, Fabrication, Testing, and Reliability of Semiconductor Lasers II, 122 (May 1, 1997); doi:10.1117/12.273825
   c. http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=918720
28) Paper: Parallel interconnect for a novel system approach to short distance high information transfer data links
   a. April 1997
   b. Proceedings of SPIE, ISSN 0277-786X, 04/1997, Volume 3038, Issue 1
   c. http://www.deepdyve.com/lp/spie/parallel-interconnect-for-a-novel-system-approach-to-short-distance-RFreDaEJjb
29) Paper: Vertical cavity surface emitting laser packaging with auto power control
   a. May 1997
   b. Proceedings, 47th Electronic Components and Technology Conference, pp. 368-370, May 1007
   c. http://www.researchgate.net/publication/3700010_Vertical_cavity_surface_emitting_laser_packaging_with_auto_powercontrol
30) Course (peer reviewed): "Optoelectronic devices and packaging"
   a. May 1997
   b. IEEE ECTC
   c. http://www.ectc.net
31) Paper: Vertical cavity surface emitting laser packaging with auto power control
   a. 18th May 1997
   b. Electronic Components and Technology Conference, 1997. Proceedings., 47th
   c. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=606195&contentType=Conference+Publications&sortType%3Dasc_p_Sequence%26filter%3DAND(p_IS_Number%3A13278)
32) Invited Talk and Abstract: VCSEL/detector technology for parallel optical interconnects
   a. 17th Jun 1997
   b. International Workshop for new technologies, interconnects, and communications in distributed and parallel systems by IRIT, ONERA, CERT, CNRS, and LAAS (France)
33) Invited talk and abstract: Vertical cavity surface emitting lasers and applications
   a. Sep 1997
   b. European Laser Workshop, Glasgow, Scotland

1998

34) Course and Tutorial: Optoelectronic Devices and Packaging: VCSEL Technology
   a. Jan 1998

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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b. "Optoelectronic devices and packaging have found increasing use in many new products over the last 20 Yrs. This tutorial primarily will focus on semiconductor laser based technology with particular emphasis on emerging new technologies such as the Vertical Cavity Surface Emitting Laser (VCSEL) and how to take advantage of itâ€™s uniqueness in packaging. The tutorial will look at the driving factors required for low cost high volume VCSEL based packages and what impact they will have in tomorrows products. As there are many packaging solutions for VCSEL based technology proposed, the course will show the relative merits of popular new technologies with respect to high volume and low cost manufacturing.
c. 4th IEEE Workshop on AST Phoenix Research Center
d. http://www.ewh.ieee.org/soc/cpmt/ast98/lebby-01.ppt

35) Paper: ORMOCERs - new photo-patternable dielectric and optical materials for MCM-packaging
a. Jan 1998
b. Hybrid inorganic-organic polymers (ORMOCERs*) have been developed and tested in an ongoing EU-program (BE 7250 DONDOMCM) for evaluation in MCM applications. The photopattemable materials with negative resist behavior are composed o f inorganic oxidic structures cross-linked or substituted by organic groups. They are prepared from organosilane precursors by sol-gel-processing in combination with organic crosslinking of polymerizable organic functions. As a result of these functionalities the properties of the ORMOCERs can be adjusted to particular applications. Systematic variation of composition combined with adaptation to micro system technology allows great flexibility in processing. Some features of these materials are: Postbaking at moderate temperatures (120 "C - 180 "C) enables processing on substrates such as FR-4 and BT. Combined use as dielectric and passivation layers in electrical systems and devices as well as core and cladding for optical applications enables e/o applications with high integration levels. Easily adaptable to thin film technology: spin-on with planarization >90% and via diameters down to 20 pm have been achieved
c. Proceedings of the 1998 48th Electronic Components and Technology Conference
d. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=678838&contentType=Conference+Publications

36) Paper and Invited talk: VCSEL Devices and Packaging for Fiber Optic Transceivers
a. 30th Mar 1998
b. OSA Technical Digest: Integrated Photonics Research (IPR) 1998 paper: IWD1
c. http://www.opticsinfobase.org/abstract.cfm?URI=IPR-1998-IWD1

37) Paper: Automatic power control of a VCSEL using an angled lid TO56 package
a. May1998
b. 1998 Proceedings. 48th Electronic Components and Technology Conference

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
1 Hawthorne St., unit 25a, San Francisco, CA 94105, USA; mobile +1 717 839 7078; drmlebby@gmail.com

c. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=678694&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel4%2F5582%2F14953%2F00678694.pdf%3Farnumber%3D678694

38) Paper: O/e-MCM packaging with new, patternable dielectric and optical materials
   a. May 1998
   b. Electronic Components & Technology Conference, 1998. 48th IEEE
   c. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=678929&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel4%2F5582%2F14953%2F00678929.pdf%3Farnumber%3D678929
39) Paper: ORMOCERs(TM)-new photo-patternable dielectric and optical materials for MCM-packaging
   a. May 1998
   b. Hybrid inorganic-organic polymers (ORMOCERs*) have been developed and tested in an ongoing EU-program (BE 7250 DONDOMCM) for evaluation in MCM applications. The photo-pattemable materials with negative resist behavior are composed of inorganic oxidic structures cross-linked or substituted by organic groups. They are prepared from organosilane precursors by sol-gel-processing in combination with organic crosslinking of polymerizable organic functions. As a result of these functionalities the properties of the ORMOCERs can be adjusted to particular applications. Systematic variation of composition combined with adaptation to micro system technology allows great flexibility in processing. Some features of these materials are: Post baking at moderate temperatures (120 "C - 180 "C) enables processing on substrates such as FR-4 and BT. Combined use as dielectric and passivation layers in electrical systems and devices as well as core and cladding for optical applications enables e/o applications with high integration levels. Easily adaptable to thin film technology: spin-on with planarization >90% and via diameters down to 20 pm have been achieved
   c. 1998 Proceeedings. 48th Electronic Components and Technology Conference
   d. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=678838&contentType=Conference+Publications
40) Course (peer reviewed): "Optoelectronic devices and packaging: VCSEL technology"
   a. May 1998
   b. IEEE ECTC
   c. http://www.ectc.net
41) Co-Chairman Optoelectronics session, 48th ECTC Conference
   a. 25th May 1998
   b. Co-chairman Optoelectronics session, 48th ECTC Conference Seattle, Washington
   c. ECTC, IEEE-CPMT, EIA/ECA
   d. http://www.ectc.net
42) Invited Presentation and Abstract: VCSEL Technology - VCSEL technology is discussed with the work between AMP and MODE (division of EMCORE) fiber optics.

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a. Sep 1998
b. ECOC European Laser Workshop (in association with ECOC 1998, Madrid, Spain
c. https://openlibrary.org/books/OL22322573M/ECOC_'98_24th_European_Conference_on_Optical_Communication
d.

43) Paper: Optical bistability in vertical cavity surface emitting lasers with a simple intra-cavity epitaxial absorber layer
    a. 4th Oct 1998
    b. Conference Digest: Semiconductor Laser Conference, 1998. ISLC 1998 NARA. 1998 IEEE 16th International
44) Talk: Optical bistability in vertical cavity surface emitting lasers with a simple intra-cavity epitaxial absorber layer
    a. 4th Oct 1998
    b. Conference Digest: Semiconductor Laser Conference, 1998. ISLC 1998 NARA. 1998 IEEE 16th International
    c.
45) Paper: Vertical cavity surface emitting laser-based parallel optical data link
    a. Dec 1998
    b. Optical Engineering, vol 37, no. 12, pp.3113-18, Dec. 1998.
    c. http://spie.org/x648.html?product_id=318648
46) Paper: VCSEL devices and packaging
    a. Dec 1998
    b. Proceedings of SPIE, ISSN 0277-786X, 05/2003, Volume 3289, Issue 1
    c. http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=935769

1999

47) Paper and Interviewed Article: Commercial VCSEL Manufacturing
    a. Apr 1999
    b. Compound Semiconductor
48) Course (peer reviewed): "Optoelectronic devices and packaging: VCSEL and edge emitter technology"
    a. May 1999
    b. IEEE Electronics and components technology conference; San Diego, California
    c. http://www.ectc.net

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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2000

49) Invited Panel Session: Opto Electronic Integrated Circuits - More IC than OE?
    a. 5th Mar 2000
    b. "The panel session focused on optical integration for communications. Other panel members included Brendan Hyland CEO of Kymata amongst others.
    c. OSA Executive Forum: Photonics and Telecommunications: the tidal wave of the new millennium
    d. http://www.laserfocusworld.com/articles/2000/02/osa-executive-forum-at-ofc-2000.html
50) Course: Optoelectronics Components and Modules for Datacom and Telecom
    a. May 2000
    b. Optoelectronics components and modules for the Telecommunication industry and Datacom Networks are rapidly advancing in terms of speed, lower cost and design. The main objectives of this course are to review the current and future trends for active devices and packaging technology for discrete components and data network modules. The course will cover in detail the fundamental active III-V devices and components used today and review current trends in both III-V device technology and packaging for telecom and datacom applications.
    c. Proceedings 50th Electronics Components and Technology Conference May 2000
    d. http://www.thierry-lequeu.fr/data/Ectc/ECTC2000/ECTC2000.pdf
51) Invited Presentation and Abstract: An investor's perspective on optical interconnects
    a. 24th May 2000
    b. The talk discusses the investor's perspective on optical interconnects from Intel Capital.
    c. IEEE: Workshop on interconnections within high=speed digital systesm
    d. http://www.oi-ieee.org/
52) Invited Presentation: Optoelectronic Integration for Metro DWDM: Intel's perspective...
    a. 3rd Sep 2000
    b. As part of the ECOC conference in Munich Germany, this workshop invited 9 speakers to discuss the future of optical networking in metropolitan environments.
    c. Electronicast Europe
    d. http://www.electronicastconsultants.com
53) Keynote Presentation: Optoelectronics Integration for Metro DWDM, Intel's Perspective
    a. 9th Oct 2000
    b. Electronicast Corporations: Optical communications start-up and emerging companies conference
    c. http://www.electronicastconsultants.com
54) Panel Session: Semiconductors to Optics
    a. 6th Nov 2000

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b. Representing Intel at the conference, the panel explored the reasons why Intel was investing into photonics, optics, and fiber optic communications. Panel moderator was Drew Lanza, VC Morgenthaler.
c. JP Morgan communications components conference: the convergence of optical components and communications ICs
d. http://www.thefreelibrary.com/Endwave+Founder+and+EVP+To+Speak+at+JP+Morgan+Communications...-a067529552

2001

55) Paper: Optical components and their role in optical networks
   a. 2001
   b. Electronic Components and Technology Conference, 2001. Proceedings., 51st
   c. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=927765&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D927765
56) Invited Presentation: "Starting a company and hitting the ground running"
   a. 7th Feb 2001
   b. Storm Ventures limited partner meeting
   c. http://www.stormventures.com
57) Keynote Talk: Industry 'Optomism'
   a. 30th Apr 2001
   b. Electronicast; Fiber Optics for the next decade conference; 13th Annual Monterey conference http://www.electronicastconsultants.com
58) Keynote Talk: Next decade in fiber optic communications
   a. 1st May 2001
   b. Electronicast: 13th Annual Fiber Optics for the Next Decade Conference
   c. http://www.photonics.com/Article.aspx?AID=8916
59) Panel session: Next decade in fiber optic communications
   a. 2nd May 2001
   b. Electroicast: 13th Annual Fiber Optics for the Next Decade Conference
   c. http://www.photonics.com/Article.aspx?AID=8916
60) Paper: OEICs: commercialization at last
   a. Jul 2001
   b. Compound Semiconductor, vol. 7. no. 6, pp. 81-2, 85, July 2001
   c. http://www.compoundsemiconductor.net/csc/features-details.php?cat=features&id=11719

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2002

61) Book chapter: "Optical sources: Light-emitting diodes and laser technology"
    a. Published 2002
    b. "The Handbook includes chapters on all the major industry standards, quick reference tables, helpful appendices, plus a new glossary and list of acronyms. This practical handbook can stand alone or as a companion volume to DeCusatis: Fiber Optic Data Communication: Technological Advances and Trends (February 2002, ISBN: 0-12-207892-6), which was developed in tandem with this book.
    c. Academic Press (1998, 2002); ISBN: 0-12-207892-6; Handbook of Fiber Optic Data Communication By Casimer DeCusatis
    d. http://books.google.com/books?id=Rlb61Kknl8IC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
62) Book chapter: "Semiconductor laser and light emitting diode fabrication"
    a. Published 2002
    b. "The Handbook includes chapters on all the major industry standards, quick reference tables, helpful appendices, plus a new glossary and list of acronyms. This practical handbook can stand alone or as a companion volume to DeCusatis: Fiber Optic Data Communication: Technological Advances and Trends (February 2002, ISBN: 0-12-207892-6), which was developed in tandem with this book.
    c. Academic Press: Editor DeCusatis: Fiber Optic Data Communication: Technological Advances and Trends (February 2002, ISBN: 0-12-207892-6)
    d. http://books.google.com/books?id=Rlb61Kknl8IC&lpg=PP1&pg=PP1#v=onepage&q&f=false
63) Keynote speech: "Business and Technical Perspectives for Optical Networking
    a. 14th Jul 2002
    b. PhoPack 2002 Stanford University
    c. http://www.accessmylibrary.com/coms2/summary_0286-25792277_ITMhttp://books.google.com/books/about/LEOS_88.html?id=LUS0cQAACAAJ
64) Interview Optcon (Japan), "Ignis Optics: Small is beautiful"
    a. 15th Aug 2002
    b. Overview of Ignis Optics strategy for fiber optic transceivers with innovative optoelectronic devices and packaging (in Japanese).
    c. Optcon volume 8, no 161, pp50-51
    d. http://magissuelist.nichigai.co.jp/detail?id=000000098732
65) Panel Session: An adventure into venture capital - lessons from silicon valley
    a. 12th Sep 2002
    b. Evening forum discussion chaired by Professor Richard Harrison, Chair, with panel members Pitch Johnson (VC), Brendan Hyland (Nutrior Ventures), Jane

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Karwoski (All-hotels Ltd), and Colin Rutherford (Intelli Partners). Sponsored by Scottish Development International, University of Edinburgh, British Council

66) Invited Paper: Elegant cost-effective optical subsystems for next generation optical networks
    a. 13th Nov 2002
    b. Electronicast: 4th Annual OADM and advanced photonics communication networks conference - market and technology trends, San Mateo, California
    c. http://www.electronicastconsultants.com/

2004

67) Invited Paper (extended abstract) and Presentation: Automated commercial fabrication of wideband tunable lasers using ultra-high resolution e-beam lithography
    a. 27th Oct 2004
    b. IoP/CS-MAX extended abstract at the Compound Semiconductor Manufacturing Expo, Monterey, California, pp92-94 in the technical digest.
    c. http://www.compoundsemiconductor.net

2005

68) Book: Optoelectronic Markets 2005
    a. Jun 2005
    b. Comprehensive market report and forecast of current optoelectronics markets, needs, technologies, and applications. This report forecasts the current state and direction of the optoelectronics industry.
    c. OIDA
    d. http://www.oida.org/home/publications/oida-publication-report-library/
69) Cover story/Interview: Does a foundry model add up for InP optoelectronics
    a. Jul 2005
    b. Interview with Michael Hatcher from Compound Semiconductor magazine. Volume 11, Number 7, August 2005 pp 17-19
    c. Compound Semiconductor: Three-fives and silicon heterostructures
    d. http://www.compoundsemiconductor.net
70) Short Article: President's Letter to OIDA Membership
    a. Nov 2005

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b. OIDA Newsletter, quarterly from 2005-2009
c. http://www.wsr-ods.com/files/oidanews_0408.pdf

71) Invited talk: Worldwide Optoelectronic Trends and Economic Opportunities.
a. 18th Nov 2005
b. UNCC 4th Annual symposium: UNC Charlotte Center for Optoelectronics and Optical Communications
c. http://opticscenter.uncc.edu/node/275

2006

72) Workshop: 100 Gb Ethernet: The Next Challenge for Communications Systems
a. 1st Oct 2006
b. Workshop chairman and editor of the report: Abstract: The communications market is continuously evolving to provide better and cheaper services. These changes have led to the movement away from the traditional voice-switched networks to more data-centric packet networks. This report seeks to examine the next generation of Ethernet devices as we strain the technology limits at 100 Gb/s? How will datacom and telecom networks differ in their approaches? OIDA http://www.oida.org/home/publications/oida_publication_report_library/100_gb_ethernet_the_next_challenge_for_communi_(1)/
c.

73) Workshop: The Challenge for Indium Phosphide Photonic Development and the Optical Foundry
a. 2006
b. "Workshop chairman and editor of the report.
c. Abstract: Indium Phosphide, InP, is a semiconductor material with properties that make it particularly suitable for optoelectronic devices. Optical communications requirements drove its initial development. Recently, the applications for InP semiconductor devices have broadened to include high-speed electronics and optical sensors. This report examines the current state of the InP device market and its future direction. Addresses challenges for a pure foundry play and the role for InP devices. Seeks to find the best ways to address the needs for InP device development in the U.S."
d. OIDA
e. http://www.oida.org/home/publications/oida_publication_report_library/the_challenge_for_indium_phosphide_photonic_develo/

74) Workshop: Nitride LED and Laser Technology and Its Impact on the Display, Medical, and Storage Industries
a. 2006

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b. Workshop chairman and editor of the report:
c. Abstract: Since the development of p-type material in 1989, research in nitride emitter technology has developed rapidly over the last 15 years. This material system provided a new range of color applications that could be better utilized and with far better reliability than the II-VI material system. This report examines material systems and developments for short wavelength (green-ultraviolet) lasers and LEDs with techniques such as color-mixing and phosphor conversion.
d. OIDA
e. http://www.oida.org/home/publications/oida_publication_report_library/nitride_led_and_laser_technology_and_its_impact_on/
f.

75) Invited Article: A New Model for the Optoelectronic Indium-based Semiconductor Industry
a. May 2006
b. OSA: Optics and Photonics News
c. http://www.osa-opn.org/Content/ViewFile.aspx?id=10456

76) Book: Worldwide Optoelectronics Markets and Trends 2006
a. Jun 2006
b. Comprehensive market report and forecast of current optoelectronics markets, needs, technologies, and applications. This report forecasts the current state and direction of the optoelectronics industry.
c. OIDA, 431 pages
d. http://www.oida.org/home/publications/oida_publication_report_library/2006_global_optoelectronics_industry_market_report/

77) Workshop: High Power Diode Laser Sources and Their Impact on Industrial, Medical, and Military Laser Industries
a. 1st Jul 2006
b. Workshop chairman and editor of the report:
c. Abstract: High power semiconductor laser diodes are used in several different market segments today. The technology continues to advance and improvements in efficiency and power are reported each year. Semiconductor laser diodes are used either directly or indirectly to enable new applications or as a replacement for older technology approaches. This report examines practical implementations and limitations for lasers in the 100 W to 100 kW range and roadmaps and developments anticipated over the next five years.
d. OIDA
e. http://www.oida.org/home/publications/oida_publication_report_library/high_power_diode_laser_sources_and_their_impact_on/

78) Workshop: Biophotonic Sensors and Smart Fiber Optic Sensor Networks
a. 1st Aug 2006
b. Workshop chairman and editor of the report:
c. Abstract: This roadmap report examines biophotonic sensor opportunities from many perspectives including; government, industrial, university and venture

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capital. The markets, technologies, commercialization, and roadmap trends are presented in addition to promising areas for R & D.
   d. OIDA
   e. http://www.oida.org/home/publications/oida_publication_report_library/biophotonic_sensors_and_smart_fiber_optic_sensor_n/

79) Workshop: Wide Area Surveillance
   a. 1st Oct 2006
   b. Workshop chairman and editor of the report:
   c. Abstract: This report examines wide area surveillance of pipelines and other strategic infrastructure as it is rapidly becoming an important issue on a worldwide basis. The increasing need for surveillance for both homeland security as well as defense applications should make this commercially attractive to both the defense as well as to commercial industry. (Report is 62 pages followed by hard copies of presentations from the forum.)
   d. OIDA
   e. http://www.oida.org/home/publications/oida_publication_report_library/wide_area_surveillance/

80) Invited Talk: OIDA optoelectronics markets, technology and opportunities for optofluidics
   a. 20th Oct 2006
   b. Organized by the DARPA center for optofluidics: translational research and commercialization workshop.
   c. DARPA Optofluidics industry forum, UCSD San Diego, CA
   d. http://www.biophot.caltech.edu/optofluidics/

81) Invited talk: Global optoelectronics technology roadmaps and trends
   a. 27th Oct 2006
   b. UNCC 5th Annual Symposium: UNC Charlotte Center for Optoelectronics and Optical Communications
   c. http://opticscenter.uncc.edu/node/268

82) Workshop: Artificial vision systems
   a. 1st Dec 2006
   b. Workshop chairman and editor of the report:
   c. Abstract: The ability to identify objects of interest and emerging threats around a vehicle in real time or by a warfighter looking for threats in a large field of view is currently severely hampered by the limitations of current algorithms and processing platforms. There have been recent advances in several technology areas, which if combined intelligently could solve this hard problem in enhancing situational awareness cost effectively. This report looks at the issues surrounding automated surveillance systems specifically looking at enhanced binoculars and convoy vehicle automated protection systems.
   d. OIDA
   e. http://www.oida.org/home/publications/oida_publication_report_library/artificial_vision_systems/

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83) Keynote address: Global perspectives in optoelectronics and photonics
    a. 6th Dec 2006
    b. Photonics 21: European Union's 7th Framework Program Key Photonics Platform
    c. http://www.photonics21.org/downloads/download_presentations.php

2007

84) Workshop: Micropackaging for the Next Generation of Optical and Electrical Components
    a. 2007
    b. Workshop chairman and editor of the report:
    c. Abstract: Optical components are ubiquitous. Applications that use them include DVD players, audio devices, cell phones, re-writable drives, projection displays, and communication devices. This report concentrates on the role of micropackaging for the for next generation fiber optic components with an eye towards lower cost and higher volume.
    d. OIDA
    e. http://www.oida.org/home/publications/oida_publication_report_library/micropackaging_for_the_next_generation_of_optical/
85) Workshop: Silicon Photonics: Challenges and Future, 2007
    a. 2007
    b. Workshop chairman and editor of the report:
    c. Abstract: Copper interconnects are currently used extensively within the data center environment. Fiber optic technology is used as a connectivity solution when higher performance is required and the cost differential compared to a copper solution is affordable. Fiber optic technology offers several key advantages over copper solutions for data transmission. This report looks at silicon photonics as a potential optical interconnect solution and addresses the issues and technology paths being pursued.
    d. OIDA
    e. http://www.oida.org/home/publications/oida_publication_report_library/silicon_photonics_challenges_and_future,_2007/
86) Workshop: Photonic Sensors Roadmapping Report, 2007
    a. 2007
    b. Workshop chairman and editor of the report:
    c. Abstract: This OIDA workshop report examines application specific sensor needs for both the government and the private sector with an emphasis on the oil and gas market, sensing function integration, cost reduction opportunities, and barriers and competing technologies.

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   d. OIDA
   e. http://www.oida.org/home/publications/oida_publication_report_library/photonic_sensors_roadmapping_report,_2007/

87) Paper: Fiber optic sensing technology: emerging markets and trends
   a. 2007
   b. Third European Workshop on Optical Fibre Sensors.
   c. Edited by Cutolo, Antonello; Culshaw, Brian; Lopez-Higuera, Joshua Miguel.
   d. Proceedings of the SPIE, Volume 6619, pp. 661902 (2007). (SPIE Homepage)
   e. http://adsabs.harvard.edu/abs/2007SPIE.6619E...2H

88) Article: "Optoelectronics Technology: New and Exciting Markets in Consumer and Entertainment"
   a. 10th Jan 2007
   b. "The total optoelectronics components and enabled products grew 20% in 2005 to $364 billion, from $304 billion in 2004. Components grew 17% in 2005 to $104 billion, from $89 billion in 2004. When flat panel displays are excluded as components, components grew 10% in 2005 to $30 billion, from $27 billion in the previous year. Enabled products grew 21% to $260 billion in 2005, from $215 billion in 2004.
   c. IEEE CPMT Santa Clara
   d. http://www.cpmt.org/scv/meetings/cpmt0701.html

89) Abstract and conference invited talk: The case for a photonics foundry in USA
   a. 27th April 2007
   b. European Conference on Integrated Optics (2007): Towards foundries for photonic ICs
   c. http://www.epixnet.org/index.php?id=393

90) Paper: Optoelectronics Roadmap OIDA-iNEMI
   a. May 2007
   b. IEEE Packaging and Assembly

91) Workshop: 100 Gbit Interconnects and Above: The Need for Speed
   a. 1st May 2007
   b. Workshop chairman and editor of the report:
   c. Abstract: The electronic society we live in today is seeing increased demand for data transfer, internet downloads, online applications, video sharing and storage. The electronic world of banks, companies, universities and governments require large secure datacenters connected to secure networks. This continuously drives for the development of more powerful servers and computer systems. This report examines needs and motivations for optical interconnect implementation. Looks at the applications, history, market drivers, and future issues that affect this crossover.
   d. OIDA
   e. http://www.oida.org/home/publications/oida_publication_report_library/100_gb_ethernet_the_next_challenge_for_communicati/

92) Book: 2007 Global Optoelectronics Industry Market Report and Forecast

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a. Jun 2007
b. Comprehensive market report and forecast of current optoelectronics markets, needs, technologies, and applications. This report forecasts the current state and direction of the optoelectronics industry.
c. OIDA, 517 pages
d. http://www.oida.org/home/publications/oida_publication_report_library/2007_global_optoelectronics_industry_market_report/

93) Paper: Growing at light speed
a. The article discusses the significance of optoelectronics in high technology manufacturing industries. Optoelectronics components are being used in the manufacturing cameras of mobile phones, plasma display panel TVs and LCD TVs, among others. Since its application allows product differentiation and innovation, it has spurred growth in segments such as the consumer/entertainment, computer and communications industries. The article also discusses the differences in the material and processing equipment such as silicon photonics.
b. Sep 2007
c. IEEE Circuits Assembly; Sep 2007, Vol. 18 Issue 9, p44
d. http://www.thefreelibrary.com/Growing+at+light+speed%3a+after+a+false+start%2c+OE+is+fast+becoming+a...-a0168812805

94) Keynote/special invited talk: "10 Grand Challenges in Photonics"
a. 31st Oct 2007
b. Sixth annual symposium UNCC Optoelectronics Center
c. http://opticscenter.uncc.edu/node/265

2008

95) Workshop: Perspectives on the Optoelectronics Industry: Manufacturing in the 21st Century, 2008
a. 2008
b. Workshop chairman and editor of the report:
c. Abstract: This report provides insight and perspectives by senior-level representatives from industry on global trade and manufacturing practices in the field of optoelectronics. Three areas examined are: 1) Can automation or optical integration relieve the momentum to outsource and off-shore manufacturing from North America? 2) The supply chain and the economics of manufacturing in the U.S., Europe, and Asia, and 30 The implications of offshore manufacturing on both the U.S. defense and commercial market sectors within the different fields of optoelectronics.

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d. OIDA
e. http://www.oida.org/home/publications/oida_publication_report_library/perspectives_on_the_optoelectronics_industry_manuf/

96) Workshop: Perspectives on the Optoelectronics Industry: Innovation, 2008
a. 2008
b. Workshop chairman and editor of the report: Abstract: This report documents some of the issues raised at the Optoelectronics Industry Development Association (OIDA) forum and provides a review on the critical issue of innovation in the U.S. and the impact it has on future American competitiveness and technology leadership. This report looks at innovation and R&D from many perspectives: global, business. university, government funding agencies.
c. OIDA
d. http://www.oida.org/home/publications/oida_publication_report_library/perspectives_on_the_optoelectronics_industry_innov/

97) Workshop: Perspectives on the Optoelectronics Industry, 2008
a. 2008
b. Workshop chairman and editor of the report:
c. Abstract: The United States is falling behind in the manufacturing, packaging, and assembling of optoelectronics products. Innovating technology may also be imperiled. This report is the result of the first of three optoelectronic forums sponsored by the Defense Advanced Research Projects Agency (DARPA), This report details the trends, findings, and directions for optoelectronics in each of these market applications. Included in the first chapter of this report is the global optoelectronics summary that was compiled by OIDA in 2007.
d. OIDA
e. http://www.oida.org/home/publications/oida_publication_report_library/perspectives_on_the_optoelectronics_industry,_2008/

98) Workshop: Future Optical Communication Systems, 2008
a. 2008
b. Workshop chairman and editor of the report:
c. Abstract: This report examines future optical communication needs and technologies. Topics include: Networks, Core, Metro, and Access Technology, photonic integration, and markets.
d. OIDA
e. http://www.oida.org/home/publications/oida_publication_report_library/future_optical_communication_systems,_2008/

99) Book chapter: Being an Intrapreneur and Entrepreneur in the Optoelectronics Industry
a. 2008
b. This book provides actual entrepreneurial stories giving insight into the pitfalls and successes one might find in starting or even continuing with a small high-tech business. Insights into innovative, speculative, and (largely) successful new ventures, as experienced by those who went through the process, are complemented by comments and observations from others in the field including

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researchers, economists, investors, regional development agencies, technology transfer organizations, and universities. The book is recommended to entrepreneurs in all high technology disciplines and in particular for students and early career professionals. It can be also useful for undergraduate and postgraduate courses in entrepreneurship, which many institutions are currently introducing, and to those who are interested in how a high-tech business might develop.

c. SPIE: Engineering a High-Tech Business: Entrepreneurial Experiences and Insights By JosÃ© Miguel LÃ³pez-Higuera, B. Culshaw (Editors) ISBN 978-0-8194-7180-2
d. http://books.google.com/books?hl=en&lr=&id=wXV9tffoGeYC&oi=fnd&pg=PR9&dq=michael+lebby&ots=cYEwXIHMDC&sig=KlCtj2ZDgbOYEhnqKdHiMo6SdzA#v=onepage&q=michael%20lebby&f=false

2009

100) Workshop: Green Photonics: The Role of Optoelectronics in a Sustainable Future, 2009
   a. 2009
   b. Workshop chairman and editor of the report:
   c. Abstract: This report explores the optoelectronics expectations for green photonics technology, and forecasts the associated markets through 2020. The cultural impact for a green, clean, and energy efficient lifestyle is just beginning. Over the next decade, many innovative new products will emerge in a variety of industries that will better define and demonstrate green photonics technology. It is clear to many that a broad range of products and services that the economy will utilize over the next decade will contain optoelectronics (interchangeable with the term photonics), either as key components or as components that enable better and more efficient systems.
   d. OIDA
   e. http://www.oida.org/home/publications/oida_publication_report_library/green_photonics_the_role_of_optoelectronics_in_a_s/
101) Conference: Optomism: "Powering the green revolution through photonics"
   a. 4th Jan 2009
   b. "Co-chairman of Optomism conference with Pennwell.
   c. OIDA and Pennwell (Laser Focus World)
   d. http://www.laserfocusworld.com/articles/print/volume-45/issue-4/world-news/conference-preview-optomism-to-emphasize-lsquogreenrsquo-growth.html
102) Invited talk, short abstract, and session chairman: Energy Efficient Photonics

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a. 19th Mar 2009
b. Summary: Green photonics initiatives: The role of optoelectronics in a sustainable future...
c. European Commission: High Level Event on ICT for Energy Efficiency
d. http://ec.europa.eu/information_society/events/cf/ee09/item-display.cfm?id=2174

103) Trial & Cross: Testimony before the US-China economic and security review commission on the optoelectronics industry
a. 24th Mar 2009
b. "Expert witness and testimony on Capitol Hill
c. Final oral comments: In preparing this testimony, many people I contacted stressed the importance of decisive action by the U.S. government and industry now. Optoelectronics sits at the intersection of multiple technical disciplines. U.S. universities and industry are particularly adept at bringing diverse people together to work on complex problems. We have, by the nature of our inherent diversity, an advantage. What for many presents a challenge, for us comes naturally. Thank you for this opportunity to present our industry's perspective. "
d. United States China Commission
e. http://www.uscc.gov/hearings/2009hearings/written_testimonies/09_03_24_wrts/09_03_24_lebby_statement.pdf

104) Report: Photonics industry-university collaborations (PICs)
a. 1st Jun 2009
b. OIDA Final Technical Report
c. http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA502737

105) Paper: Green photonics technology and markets
a. Sep 2009
b. Green photonics technology will open up opportunities over the next decade for new and creative products to be designed as the interest in a green, clean and energy efficient lifestyle continues to grow. This overview forecasts the optoelectronics expectations for green photonics technology and associated markets over the next decade and explores just a few of the exciting opportunities from green photonics technology.
c. Electronics Letters, Vol 45, issue 20
d. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5270369&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F2220%2F5270368%2F05270369.pdf%3Farnumber%3D5270369

106) Paper: Photonic Intgeration: what is the Holy Grail?
a. 14th Oct 2009
b. Compound Semiconductor
c. http://compoundsemiconductor.net/csc/features-details.php?id=40435

107) Keynote talk: Global optoelectronics and green photonics trends
a. 28th Oct 2009
b. UNCC 8th Annual Symposium: Optoelectronics Center

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c. http://opticscenter.uncc.edu/node/255

108) Keynote talk and abstract: Is this the rise of green photonics?
a. Dec 2009
b. ICFO (Institut de Ciancies Fotoniques) Barcelona, Spain
c. http://www.icfo.es/images/news/ICFO%20CLP%20DAY%20Program.pdf

109) Book: 2009 Global Optoelectronics Industry Market Report and Forecast
a. Dec 2009
b. Comprehensive market report and forecast of current optoelectronics markets, needs, technologies, and applications. This report forecasts the current state and direction of the optoelectronics industry.
c. OIDA, 545 pages
d. http://www.oida.org/home/publications/oida_publication_report_library/2009_global_optoelectronics_industry_market_report/

110) Video presentation: Living at the speed of light
a. 10th Dec 2009
b. Living at the speed of light, hosted by renown physicist Michael Lebby, takes us on a fast paced fly through of the many facets of photonics and how the use of light touches the many aspects of our lives
c. National Research Council: Canadian Photonics Fabrication Centre
d. http://www.youtube.com/watch?v=t8EB-1-1irY

111) Book chapter: Packaging of Optical Components and Systems
a. 27th Dec 2009
b. "In this article, several types of semiconductor optical components are introduced, and packaging of optical components and systems will be discussed. Specifically, three common types of optical sources will be addressed: light emitting diodes (LED), edge-emitting semiconductor lasers, and vertical cavity surface emitting lasers (VCSEL).
c. Wiley Encyclopedia of Electrical and Electronics Engineering; DOI: 10.1002/047134608X.W2106; originally published in 1999, Vol 15, pp 499-516; John G Webster (Editor)
d. http://onlinelibrary.wiley.com/doi/10.1002/047134608X.W2106/abstract

2010

112) Workshop: Fabrication Challenges and Opportunities in Photonics, 2010
a. 2010
b. Workshop chairman and editor of the report: Abstract: This report examines different operational models employed by industry (fabless, fab-lite, pure play

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foundry and vertically integrated companies), and the role of governments in stimulating the growth of the photonics industry.
   c. OIDA
   d. http://www.oida.org/home/publications/oida_publication_report_library/fabrication_challenges_and_opportunities_in_photon/

113) Video and presentation: Green Photonics: Will it Change our Lives over the Next Decade?
   a. April 2010
   b. Photonics is growing to enable new green technologies and products. Photonics already has a large presence in various modules and components with opportunities to expand to home displays, solar cells, lighting, and various consumer applications. The global optoelectronics industry has a strong outlook for growth in the near future, with even faster growth in green photonics. Green photonics can help reduce greenhouse gas emissions, generate or conserve energy, reduce pollution, and improve human health.
   c. University of California, Santa Barbara: Institute of Energy Efficiency
   d. http://iee.ucsb.edu/node/1024

114) Conference and workshop: 3rd Annual Green Photonics Forum (OIDA Green 2010)
   a. 10th Jun 2010
   b. Conference chairman: OIDA's innovative green photonics forums have become a focal point for photonics and optics in the area of sustainable energy. The annual forum on green photonics, brings together key players involved in developing the technical and business roles of photonics in building a more sustainable and renewable future. Efficiency, monitoring, and energy generation are areas where photonics technology will play a key role and the photonics industry will deliver solutions.
   c. OIDA
   d. http://www.clocate.com/conference/3rd-Annual-Green-Photonics-Forum-OIDA-Green-2010/4045/

115) Paper: Silicon light emitting device based on rare earth oxide superlattice
   a. Sep 2010
   b. 7th IEEE International conference on Group IV photonics, Beijing China
   c. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5643407&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F5623516%2F5643317%2F05643407.pdf%3Farnumber%3D5643407

2011

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116) Paper: Study of the Structural and Thermal Properties of Single Crystalline Epitaxial Rare-Earth-Metal Oxide Layers Grown on Si(111)
   a. 2011
   b. ECS Transactions 16, 161 (2011)
   c. http://ecst.ecsdl.org/content/41/3/161
117) Webinar and presentation
   a. 29th Mar 2011
   b. "The future of photonics webinar and presentation: The Future of Photonics: Three Perspectives brings together three expert viewpoints on the future of the photonics industry (Michael Lebby will be the expert on market trends and photonic integrated circuits (PICs)). You will learn: global optoelectronics market outlook through 2021 trends in photonic integrated circuits over the next two decades."
   c. Photonics Media
   d. http://www.photonics.com/Webinar.aspx?WebinarID=7
118) Keynote invited speech: Green Photonics and GaN-on-Si for LEDs and Ge-on-Si for high Efficiency Multi-junction for PVs
   a. Dec 2011
   b. Conference proceedings: High Capacity Optical Networks and Enabling Technologies (HONET), 2011
   c. http://honet.uncc.edu/archive/honet11/speakers.htm

2012

119) Paper: Structural and Thermal Properties of Single Crystalline Epitaxial Gd2O3 and Er2O3 Grown on Si(111)
   a. 2012
   b. ECS Journal of Solid State Science and Technology 1, N24 (2012)
   c. http://jss.ecsdl.org/content/1/2/N24.full.pdf+html
120) Paper: Epitaxial Si, SiGe and Ge on binary and ternary rare earth oxide buffers
   a. 2012
   b. Phys. Status Solidi C 9, 2031 (2012)
   c. http://onlinelibrary.wiley.com/doi/10.1002/pssc.201200255/abstract
121) Paper: Integrated high reflectivity silicon substrates for GaN LEDs
   a. 13th Jan 2012
   b. Volume 9, Issue 3-4, pages 814-817, March 2012, physica status solidi (c)
   c. http://onlinelibrary.wiley.com/doi/10.1002/pssc.201100393/abstract
122) Paper: Integrated high reflectivity silicon substrates for GaN LEDs
   a. 13th Jan 2012

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b. "Conference Publication: ICNS-9 “Contributed Article Integrated high reflectivity silicon substrates for GaN LEDs
c. F. Erdem Arkun*,Rytis Dargis, Robin Smith, David Williams, Andrew Clark, Michael Lebby
d. Article first published online: 13 JAN 2012" ICNS-9 “Contributed Article Integrated high reflectivity silicon substrates for GaN LEDs
e. http://onlinelibrary.wiley.com/doi/10.1002/pssc.201100393/abstract

123) Paper: Rare-earth-metal oxide buffer for epitaxial growth of single crystal GeSi and Ge on Si(111)
a. 1st Mar 2012
b. Conference and journal publication."Rare-earth-metal oxide buffer for epitaxial growth of single crystal GeSi and Ge on Si(111)"
c. With publication details: 28th North American Molecular Beam Epitaxy Conference, Published by AVS through the American Institute of Physics, 2012 ISBN 978-0-9836933-0-7 ISSN: 2166-27646 J.Vac.Sci.Technol B 30(2), Mar/Apr 2012 pp02B110-1 to pp-3B110-6
d. http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=6118290&contentType=Journals+%26+Magazines

124) Paper: Scalable virtual Ge templates for III-V integration on Si wafers
a. 18th April 2012
b. AIP Conference Proceedings / Volume 1477 / CONCENTRATOR SOLAR CELLS, CELL ASSEMBLIES AND RELATED MATERIALS
c. http://proceedings.aip.org/resource/2/apcpcs/1477/1/36_1?bypassSSO=1

125) Paper and talk: Engineering of the Interface Between Silicon and Rare-Earth Oxide Buffer for GaN growth
a. Sept 2012
b. ECS Meeting Oct 2013, San Francisco, USA
c. http://scholar.googleusercontent.com/scholar?q=cache:l3-oHWxNDzwJ:scholar.google.com/+%22michael+lebby%22&hl=en&as_sdt=1,5&as_ylo=2013&as_vis=1

126) Paper: Scalable GaN-on-Silicon using rare earth oxide buffer layers
a. 9th Oct 2012
b. ECS Trans 2013 volume 50, issue 9, 1065-1071
c. http://ma.ecsdl.org/content/MA2012-02/30/2538.short

2013

127) Paper: Expitaxial Si and Gd2O3 Heterostructures - Distributed Bragg Reflectors with Stress Management Function for GaN on Si Light Emitting Devices

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a. 2013
b. ECS Trans 2013 volume 50, issue 4, 47-52
c. http://ecst.ecsdl.org/content/50/4/47.short

128) Article: OPTICAL MATERIALS: 'On-silicon' engineered substrates speed photonic device development
a. 1st Apr 2013
b. Laser Focus World
c. http://www.laserfocusworld.com/articles/print/volume-49/issue-04/features/optical-materials---on-silicon--engineered-substrates-speed-phot.html

129) Paper & Poster: 100Gb/s Multi-guide vertical integration transmitter PIC in InP for fiber-optics interconnects
a. 24th Sep 2013
b. Sasa Ristic and Michael Lebby, Valery Tolstikhin, and Kirill Pimenov,
c. ECOC 2013
d. http://www.ecoc2013.org/sc2.html

130) Paper: Epitaxial Si and Gd2O3 Heterostructures - Distributed Bragg Reflectors with Stress Management Function for GaN on Si Light Emitting Devices
a. 1st Oct 2012
b. ECS J. Solid State Sci. Technol. 1, 246 (2012)
c. http://jss.ecsdl.org/content/1/5/P246.full

131) Growth of GaN by MOCVD on rare earth oxide on Si(111)
a. 31st Oct 2013
b. ECS Transactions, 58, 455 (2013)
c. http://ecst.ecsdl.org/content/58/4/455.short

132) Invited talk/plenary: Next generation ICs using photonics integration
a. 10th Dec 2013
b. Talk that reviews OneChip Photonics technology and in general PICs, OEICs, Silicon photonics, and how these technologies play into datacenters (data centers) for client side high speed 100G fiber (fibre) optic transceiver interconnects and cabling.
c. IQE Capital markets day, Sky Pavillion, Rothschild Building, London, UK
d. http://www.euroinvestor.com/news/2013/12/10/iqe-plc-capital-markets-day/12617916

133) Poster paper: A versatile InP OEIC (PIC) platform enabling 100G+ coherent receiver and client-side transceiver engines
a. 12th Nov 2013
b. Poster paper describing OneChip's latest results in coherent receivers, LR4 optical engines, and PSM4 optical engines.
c. Silicon Photonics Workshop, Southampton University, UK
d. http://www.orc.soton.ac.uk/UKSP_presents.html

134) Talk and panel session: Approaches for combining 3-5 and silicon, add functionality to Si photonics, heterogeneous versus hybrid integration, introduction of photonic platforms

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a. 5th Dec 2013
b. Short presentation on PICs, OEICs, Si photonics, and combinations of these technologies from a revenue, investment, application and technology standpoint.
c. EPIC workshop: Meet or eat? collaboration and/or competition in photonic integrated circuits (PICs)
d. http://epic-assoc.com/contact-us/?at=94

135) Invited talk: Feedback USA/International related events
a. 5th Dec 2013
b. Feedback on the subject of InP PICs, OEICs, and silicon photonics from workshops and related international events from around the globe.
c. EPIC workshop: Meet or eat? Collaboration and/or competition in Photonic Integrated Circuits (PICs)?
d. http://epic-assoc.com/contact-us/?at=94

2014

136) Invited talk/plenary: High-Performance Datacenter Platform: Using InP for Silicon Photonics
a. 8th Jan 2014
b. IEEE-CPMT/Photonics Society local chapter meeting, Santa Clara, California
c. http://www.cpmt.org/scv/meetings/cpmt1401.html

137) Invited talk/Panel session "Optical interconnect in datacenters"
a. 18th Mar 2014
b. "The 1st Optical Interconnect in Data Centers Symposium takes place on the 18th and 19th of March 2014 in Berlin/ Germany.
c. It is focused on high-performance, low-energy and low-cost and small-size optical interconnects across the different hierarchy levels in data center and high-performance computing systems: on-board, board-to-board and rack-to-rack.
d. EPIC: Symposium on optical interconnect in datacenters
e. http://www.phoxtrot.eu/1st-optical-interconnect-in-data-centers-symposium/

138) Keynote talk: Photonic integration in InP: A regrowth-free platform for fabless manufacturing model
a. 19th March 2014
b. CS International Conference Frankfurt, March 17th-20th 2014
c. http://cs-international.net/agenda.php

139) Invited talk/Panel session: InP based photonics integration platform for datacenter and coherent communications
a. 2nd April 2014

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b. Invited talk/panel session on the future of integrated photonics. Discussion was on both InP and silicon photonics technologies over the next decade.
c. Workshop on the future of Integrated Photonics organized by the Netherlands Office for Science & Technology is pleased to invite you to a workshop, occurring in conjunction with the upcoming Photonics West conference
d. http://www.hollandinthevalley.com/panel-discussion-on-the-future-of-integrated-photonics/

140) Invited talk and abstract: Coherent Receiver Chip for 100G DP-QPSK
a. 30th April 2014
b. SIOE (Semiconductor and integrated optoelectronics) Conference, Cardiff, Wales, UK 29th April-1st May 2014, Institute of Physics
c. http://www.astro.cardiff.ac.uk/research/cmp/events/resources/Sioeprogramme14final.pdf

141) Invited talk/keynote lecture: Compound semiconductors driving photonics technologies to become the future for high-speed communications through integration, performance, and sustainability
a. 12th Jun 2014
b. Glyndwr University, Wales, UK
c. http://www.glyndwr.ac.uk/en/AboutGlyndwrUniversity/Newsandmediacentre/Newsarchive/PressReleases2014/UniWeek/

142) Invited Talk/Panel session: EPIC technology workshop on Photonic Integrated Circuits (PIC) packaging standardization
a. 18th Jun 2014
b. EPIC
c. http://epic-assoc.com/contact-us/?at=94

143) Invited talk: Compound Semiconductors (CS) driving photonics
a. 11th June 2014
b. Invited presentation for Welsh Gvt and commercial industry in epitaxial growth. The talk covered photonics: global markets, green photonics, photonics technology sectors (lighting, solar, displays, sensors, communications), integrated photonics and silicon photonics. Commercial industry invite by International Quantum Epitaxy (IQE)
c. Growth and application of epitaxial heterostructures with polymorphous rare earth oxides
d. Journal of Crystal Growth
e. http://www.sciencedirect.com/science/article/pii/S0022024812009487

144) Invited presentation for Day of Photonics at Glyndwr University: Photonics - markets, applications, integrated, next generation IC
a. 21st Oct 2014
b. Invited presentation/lecture on photonics at the Glyndwr University.
c. Welsh Optoelectronic Forum (WOF)
d. http://www.wof.org.uk/home.php?page_id=4&event_id=317

145) Invited talk and moderator: Integrated photonics pilot lines

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a. 14th Nov 2014
b. "Photonics Pilot Line Workshop 14 November 2014 - Brussels, Belgium
c. European Commission and Photonics21
d. http://www.photonics21.org/download/Events/DraftagendaPhotonicsPilotLineworkshop-Website.pdf

2015

146) Invited talk: Integrated photonics roadmap synthesis
a. 7th May 2015
b. Integrated Photonics Institute for Manufacturing Innovation (IP-IMI) site visit technical review:
c. The University of Southern Californiaâ€™s (USC) Information Sciences Institute (ISI) is leading an effort with partner universities at the University of California-Los Angeles (UCLA), the University of California-Berkeley (UCB), the University of California-San Diego (UCSD), Arizona State University, the University of New Mexico, and the Ohio State University, as well as numerous industry partners, to develop the only California-based and led proposal to compete for the IP-IMI award. If successful, the proposal will receive a federal award of up to $110 million over five years. A successful proposal requires 100 percent or more in matching funds (cash or in-kind) from state and local governments and from industry partners.
d. IPI-CDMS (Integrated Photonics Institute and Center for Design and Manufacturing Services)
e. http://www.isi.edu/news/story/531784

147) Invited talk and Chair panel session: EPIC workshop on photonic integrated circuits; "Global integrated photonics update and roadmaps"
a. 9th Jun 2015
b. "Invited talk: Global integrated photonics update and roadmaps
c. Panel Session: Integrated photonics foundry status
d. EPIC trade association, Europe
e. http://www.epic-assoc.com/epic-workshop-on-photonic-integrated-circuits/

148) Keynote talk and invited abstract: "Integrated photonics as a vehicle for the next generation IC"
a. 9th Sep 2015
b. Internet Technology Applications (ITA) ITA-15 conference Wrexham, Wales, UK 8-11th Sept 2015
c. http://www.ita15.net/keynote-speaker/

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149) Press interview: "Building Big Business with the Next Generation Integrated Circuits!"
   a. 15th Sep 2015
   b. "Insights from Michael Lebby, CEO OneChip Photonics Corporation, the keynote speaker at the Photonics Integration Conference
   c. Photonics Integration Conference, organized by Jakajima, Netherlands
   d. http://www.phiconference.com/photonics/building-big-business-with-the-next-generation-integrated-circuits/

150) Project advisor: European Commission ICT-28-2015 Cross-Cutting ICT KETs: Innovation Action (b) Pilot line for OLEDs on flexible substrates
   a. 20th Sept 2015
   b. European Commission
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/916-ict-28-2015.html

151) Project advisor: European Commission ICT-28-2015 Cross-Cutting ICT KETs: Innovation Action (b) Pilot line for analytical mid-infrared (MIR) micro-sensors
   a. 22nd Sep 2015
   b. European Commission
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/916-ict-28-2015.html

152) Keynote talk and abstract: "PIC the next generation IC..."
   a. 23rd Sep 2015
   b. Photonic Integration Conference, organized by Jakajima, Netherlands
   c. http://www.phiconference.com/program/

153) Project advisor: European Commission ICT-28-2015 Cross-Cutting ICT KETs: Innovation Action (b) Pilot line for PIC fabrication on III-V and/or dielectric based platforms for PICs (Photonic Integrated Circuits)
   a. 24th Sep 2015
   b. European Commission
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/916-ict-28-2015.html

154) Session organizer/Committee member: Market Focus at ECOC exhibit 2015
   a. 28th Sep 2015
   b. Session organizer/Committee member: Market Focus at ECOC exhibit 2015 with sessions in broadband access, datacentres, service provider optical transmission, network agility/SDN, photonics integration and packet optical transport. Nexus Business Media Ltd
   c. http://webcache.googleusercontent.com/search?q=cache:Qb68vjzhV5IJ:www.ecocexhibition.com/visitorhome/marketfocus2015/cfs+&cd=1&hl=en&ct=clnk&gl=us&client=safari

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2016

155) Reviewer: European Commission ICT-29-2016: Photonics KET 2016 (section a(i) Biophotonics: advanced imaging for in-depth disease diagnosis)
   a. 10th May 2016
   b. European Commission
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/5094-ict-29-2016.html

156) Reviewer: European Commission ICT-29-2016: Photonics KET 2016 (a(iii) Pervasive high-specificity and high-sensitivity sensing for a safer environment)
   a. 12th May 2016
   b. European Commission

157) Reviewer: European Commission ICT-29-2016 Photonics KET (b) Innovation Actions (i) Application driven core photonic devices integrated in systems.
   a. 14th May 2016
   b. European Commission
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/5094-ict-29-2016.html

158) European Commission Reviewer: European Commission ICT-29-2016 Photonics KET (b) Innovation Actions (ii) Pilot line for assembly and packaging
   a. 15th May 2016
   b. European Commission
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/5094-ict-29-2016.html
   d. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/5094-ict-29-2016.html

159) Invited Talk: Annual Shareholder Meeting 2016 - Market Perspective LWLG Polymer Photonics vs Legacy Devices
   a. 20th May 2016
   b. Presentation to investor group at Lightwave Logic's Annual Shareholder Meeting Lightwave Logic
   c. http://lightwavelogic.com/company-updates/

160) Technical presentation for Lightwave Logic Inc., at the Annual Shareholder Meeting (ASM).
   a. 20th May 2016
   b. Lightwave logic Inc., Boulder, Colorado.
   c. Annual shareholder meeting for Lightwave Logic Inc., with live presentation with live Q&A from investors

161) Invited Presentation and abstract: "High-Performance Polymer Photonics for Next-Generation Photonic Integrated Circuits"
   a. 3rd Oct 2016

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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b. ECOC Market Focus by ECOC Exhibition
c. http://www.ecocexhibition.com/marketfocus

162) Video Interview: ECOC Market Focus on Datacenters and emerging new PIC technologies that include silicon and polymer photonics
a. 3rd Oct 2016
b. Video taped interview by ECOC Exhibition Market Focus on Datacenters and emerging new PIC technologies that include polymer photonics.
c. ECOC Exhibition
d. http://www.ecocexhibition.com/interviews2016

163) Panel session: European Commission ICT-29-2016: Photonics KET 2016 (section a(ii) Breakthrough in miniaturization of SSL light engines and systems); comment on industry and academic technology.
a. 5th Nov 2016
b. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/5094-ict-29-2016.html

164) Reviewer: European Commission ICT-29-2016: Photonics KET 2016 (section a(ii) Breakthrough in miniaturization of SSL light engines and systems)
a. 5th Nov 2016
b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2020, and rate proposals to EU guidelines.
c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/5094-ict-29-2016.html

2017

165) Invited Talk and Panelist: Emerging Technologies Summit; Integrated Photonics session, Stanford University, as part of the Kingdom of the Netherlands trade mission to Silicon Valley
a. 10th Jan 2017
b. "Discussion with HRH Prince Constantijn and DG Bertolt Leeftink about photonics ecosystem and startups. Photonics highlights (Michael Lebby)
c. Consulate General San Francisco, The Kingdom of Netherlands
d. https://ez.atavist.com/emerging-technologies-summit

166) Video: The importance of photonics roadmapping
a. 30th Jan 2017
b. Video on the importance of roadmapping photonics technologies at Photonics West San Francisco, 30th Jan 2017. Interview by Photon Delta.
c. http://www.photondelta.eu

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167) Technical Advisor/Expert: 2nd review of MIRPHAB pilot line consortium funded by H2020 at European Commission
   a. 20th Feb 2017
   b. 2nd review for MIRPHAB consortium at the European Commission, Brussels
   c. European Commission, Brussels
   d. https://www.iaf.fraunhofer.de/en/research/research-areas/semiconductor-lasers/mirphab.html
168) Technical Advisor/Expert: 2nd review of PI-SCALE project pilot line funded by H2020, European Commission
   a. 21st Feb 2017
   b. 2nd review of PI-SCALE consortium pilot line at European Commission, Brussels
   c. European Commission, Brussels, Belgium
   d. http://pi-scale.eu
169) Technical Advisor/Expert: 1st review of PIXAPP pilot line consortium funded by H2020 at European Commission
   a. 21st Feb 2017
   b. 1st Review of Pixapp project at EU Commission as part of the pilot line project.
   c. European Commission, Brussels
   d. http://www.fabiodisconzi.com/open-h2020/projects/206352/index.html
170) Invited Talk: Belgium LWLG Investor Group at the Royal Antwerp Golf Club
   a. 6th Mar 2017
   b. Invited talk entitled "High performance polymer photonics for next generation PICs"
   c. Belgium LWLG Investor Group
   d. http://www.lightwavelogic.com
171) Chairman: PIC (Photonic Integrated Circuits) International Conference, Brussels, Belgium
   a. 7th Mar 2017
   b. "Photonic Integrated Circuits International
   c. CS International
   d. http://www.picinternational.net
172) Invited Talk: Photonics Integration Circuits - Global Market Analysis 2017
   a. 13th Mar 2017
   b. Invite by The Netherlands Department of Economics to review PIC technology and markets for potential investment.
   c. The Dutch Government - Dept of Economics, The Hague together with Photon Delta, The Netherlands
   d. http://www.photondelta.eu
173) Technical Advisor/Expert: 2nd review of PIX4LIFE pilot line consortium funded by H2020 at European Commission
   a. 14th Mar 2017

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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b. 2nd review of PIX4LIFE pilot line consortium at the European Commission, Brussels.
c. European Commission, Brussels, Belgium
d. http://www.pix4life.eu

174) Keynote talk: Entitled "The rise of PIC based technologies over the next decade and how datacenters and telecom may enable other exciting applications"
a. 1st May 2017
b. Xilinx as part of their; "Xilinx silicon technology series seminars"
c. http://www.xilinx.com

175) Invited Talk: Lightwave Logic Inc Annual Shareholder Meeting "High Performance Polymer Photonics for Next Generation PICs"
a. 18th May 2017
b. Presentation of corporate technology and strategy for Lightwave Logic Inc and polymer PIC platforms.
c. Lightwave Logic Inc (OTCQB:LWLG)
d. http://www.lightwavelogic.com/presentations

176) Management/CEO presentation for Lightwave Logic Inc., at the Annual Shareholder Meeting (ASM).
a. 18th May 2017
b. Lightwave logic Inc., Boulder, Colorado.
c. Annual shareholder meeting for Lightwave Logic Inc., with live presentation with live Q&A from investors.

177) Plenary Talk: Global Market Research at the World Technology Mapping Forum, s'Hertogenbosch, Netherlands
a. 14th Jun 2017
b. "PhotonDelta and the AIM Photonics Academy are organising the first meeting of the World Technology Mapping Forum. The goal of the forum is to produce the first International Photonic Systems Roadmap, looking ahead to global technology needs in 2030 and beyond.
c. PhotonDelta, Netherlands as part of the International Photonics System Roadmap (IPSR) conference
d. https://worldtechnologymappingforum.org/the-programme

178) Video interview: World Photonic Mapping Forum; s'Hertogenbosch, Netherlands
a. 15th Jun 2017
b. Interview on photonics roadmaps.
c. PhotonDelta (via Videographer Jonathan Marks)
d. https://worldtechnologymappingforum.org/the-programme

179) Invited video 'Lightwave Logic roadmaps for polymer photonics at the 3rd International Roadmap conference, Eindhoven, Netherlands
a. 16th June 2017
b. PhotonDelta video PR team
c. https://vimeo.com/317216466

180) Invited talk and abstract: Polymer based PICs

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a. 14th Sep 2017
b. ECOC, Datacenter technologies. Sweden

181) Video: Polymer based PICs
a. 15th Sep 2017 ECOC, Sweden as part of Market Focus at the ECOC Exhibit. (youtube: Michael Lebby ECOC 2017)

182) Keynote invited talk and abstract: PIC based technologies
a. 22nd Sep 2017
b. PIC Conference, The Netherlands

183) Invited talk and abstract: Polymer PIC technology as part of the Photonics Integrated Circuits (PIC) conference in Eindhoven, Netherlands.
a. 5th Oct 2017
b. PIC technologies and polymer photonics

184) Invited talk: PIC Training conference/workshop in Sunnyvale, Silicon Valley
a. PIC training session/workshop

185) Invited talk: Photonics Pilot Lines
a. 8th Dec 2017
b. European Commission, Photonics Proposers Meeting, Brussels

2018

186) International Roadmap meeting at Berenshot, Utrecht, Netherlands
a. 20th Jan 2018
b. Invited talk: International Roadmap meeting: Datacom/Telecom ICT markets, AOC, and Polymer PIC technology platforms

187) Co-Chairman: PIC (Photonic Integrated Circuits), International Conference, Brussels, Belgium
a. 10th Apr 2018
b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net

188) Session chair and moderator: High volume, high performance PICs (Photonic Integrated Circuits) at the International Conference, Brussels, Belgium
a. 10th Apr 2018
b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net

189) Session chair and moderator: Silicon Photonics (SiP) PICs (Photonic Integrated Circuits) at the International Conference, Brussels, Belgium
a. 11th Apr 2018

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net

190) Invited Talk: Scalable PIC platforms: "The impact of using polymer PICs for 100 and 400Gbps datacom applications," PICs (Photonic Integrated Circuits) at the International Conference, Brussels, Belgium
a. 10th Apr 2018
b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net

191) Management/CEO presentation for Lightwave Logic Inc., at the Annual Shareholder Meeting (ASM).
a. 17th May 2018
b. Lightwave logic Inc., Denver, Colorado.
c. Annual shareholder meeting for Lightwave Logic Inc., with live presentation with live Q&A from investors.

192) Invited video 'Welcome to WTMF 18' at the 2nd International Roadmap conference, Eindhoven, Netherlands
a. 12th June 2018
b. PhotonDelta video PR team
c. https://vimeo.com/275376937

193) Reviewer: European Commission ICT-03-2018: Photonics Pilot lines (InP and silicon photonics PICs)
a. 11th Jun 2018
b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2020, and rate proposals to EU guidelines.
c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

194) Reviewer: European Commission ICT-04-2018: Tbps optical fiber optic transceivers
a. 11th Jun 2018
b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2020, and rate proposals to EU guidelines.
c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

195) Reviewer: European Commission ICT-04-2018: Connected lighting
a. 11th Jun 2018
b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2020, and rate proposals to EU guidelines.
c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

196) Workgroup chair and moderator: Telecom long haul roadmap committee at the International world mapping conference, Enschede, Netherlands
a. 20th Jun 2018
b. Photondelta Conference: chairing technical workgroup meetings to address photonics roadmap trends and challenges.

Professor (Dr. Dr.) Michael S. Lebby, B. Eng. (Hons), MBA, Ph.D., D. Eng, Fellow NAI, IEEE, OSA; C. Eng.
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c. Photondelta in coordination with iNEMI, and AIM photonics.
d. https://www.photondelta.eu

197) Invited talk: Telecom, Datacom, and ICT roadmap committee at the International world mapping conference, Enschede, Netherlands
a. 20th Jun 2018
b. Photondelta Conference: chairing technical workgroup meetings to address photonics roadmap trends and challenges.
c. Photondelta in coordination with iNEMI, and AIM photonics.
d. https://www.photondelta.eu

198) Invited talk and abstract: Pushing the performance of 50Gbps NRZ polymer modulators towards 100Gbps NRZ in a PIC platform to access 400 and 800Gbps data-rates
a. 25th Sep 2018
b. ECOC, Datacenter technologies. Sweden

199) Reviewer (European Commission) for pilot line PISCALE
a. 18th Sept 2018
b. European Commission, Brussels
c. PISCALE is a pilot line that is focused on bringing to commercial market flexible organic display technologies in both panel and reel to reel formats.

200) Reviewer (European Commission) for pilot line MIPHAB
a. 19th Sept 2018
b. European Commission, Brussels
c. MIPHAB is a pilot line that is focused on bringing to commercial market near infra-red devices and packaging for industrial, defense, military and high volume applications.

201) Video: Pushing the performance of 50Gbps NRZ polymer modulators towards 100Gbps NRZ in a PIC platform to access 400 and 800 Gbps datarates.
a. 25th Sept 2018
b. ECOC, Market Focus at the ECOC Exhibit, (Youtube: Michael Lebby ECOC 2018)

202) Invited talk and abstract: ECOC International Symposium on Hybrid PICs entitled “Polymer PICs: technology and prospects"
a. 26th Sept 2018
b. International Symposium on Hybrid PICs co-located at the ECOC conference, Rome, Italy.

203) Reviewer (European Commission) for pilot line PIXAPP
a. 2nd Oct 2018
b. European Commission, Brussels
c. PIXAPP is a pilot line that is focused on bringing to commercial market PIC (photonic integrated circuit) packaging solutions for InP and silicon photonics based technologies.

204) Reviewer (European Commission) for pilot line PIX4LIFE

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a. 3rd Oct 2018
b. European Commission, Brussels
c. PIX4LIFE is a pilot line that is focused on bringing to commercial market PIC dielectric solutions for applications in the visible wavelength range in the medical applications market.

2019

205) Invited talk: Polymer modulators and polymer PIC technologies: PIC Training conference/workshop in Sunnyvale, Silicon Valley
a. 28th Jan 2019
b. PIC training session/workshop at Keysight facility
206) Reviewer (European Commission) for pilot line MIPHAB
a. 16th Feb 2019
b. European Commission, Brussels
c. MIPHAB is a pilot line that is focused on bringing to commercial market near infra-red devices and packaging for industrial, defense, military and high volume applications.
207) Reviewer (European Commission) for pilot line PIX4LIFE
a. 25th Mar 2019
b. European Commission, Brussels
c. PIX4LIFE is a pilot line that is focused on bringing to commercial market PIC dielectric solutions for applications in the visible wavelength range in the medical applications market.
208) Co-Chairman: PIC (Photonic Integrated Circuits), International Conference, Brussels, Belgium
a. 26-27th Mar 2019
b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net
209) Session chair and moderator: High volume, high performance PICs (Photonic Integrated Circuits) for Foundries at the International Conference, Brussels, Belgium
a. 26th Mar 2019
b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net
210) Session chair and moderator: High volume PICs (Photonic Integrated Circuits) at the International Conference, Brussels, Belgium
a. 27th Mar 2019

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b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net

211) Invited Talk: Polymer PICs for 400Gbps+ datacom applications," PICs (Photonic Integrated Circuits) at the International Conference, Brussels, Belgium
a. 27th Mar 2019
b. Photonic Integrated Circuits International
c. CS International
d. http://www.picinternational.net

212) Reviewer (European Commission) for project CARDIS
a. 18th Apr 2019
b. European Commission, Brussels
c. CARDIS is an EU project for PIC based technology to monitor blood flow and artery stiffness in the human body using long wavelength lasers and silicon photonics.

213) Management/CEO presentation for Lightwave Logic Inc., at the Annual Shareholder Meeting (ASM).
a. 16th May 2019
b. Lightwave logic Inc., Denver, Colorado.
c. Annual shareholder meeting for Lightwave Logic Inc., with live presentation with live Q&A from investors with presentation: https://drive.google.com/file/d/1wh8irF8rmi9bU6VeGKAHFqVURyUcytdX/view?usp=sharing

214) Reviewer: European Commission ICT-03-2019: Fiber optic communications and bio-photonics for medical applications
a. 6th June 2019
b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2020, and rate proposals to EU guidelines.
c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

215) Workgroup chair and moderator: Datacom roadmap committee at the International world mapping conference, Berlin, Germany
a. 12th June 2019
b. Photondelta Conference: chairing technical workgroup meetings to address photonics roadmap trends and challenges.
c. Photondelta in coordination with iNEMI, and AIM photonics.
d. https://www.photondelta.eu

216) Keynote speaker: 'Global markets for PIC technologies' at the 3rd International world mapping conference, at the Fraunhofer HHI, Berlin, Germany
a. 15th June 2019
b. Photondelta Conference: chairing technical workgroup meetings to address photonics roadmap trends and challenges.
c. Photondelta in coordination with iNEMI, and AIM photonics.
d. https://www.photondelta.eu

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217) Reviewer: European Commission ICT-05-2019: Pilot lines (free form optics and integrated photonics for bio-medical applications
   a. 16th June 2019
   b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2020, and rate proposals to EU guidelines.
   c. http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020
218) Invited speaker: 'Lightwave Logic polymer modulator platform' at the Spring Investor Conference, NYC, NY
   a. 2nd April 2019
   b. Spring Investor Summit (Microcap Conference) (www.springinvestorsummit.com
219) Invited video 'Lightwave Logic polymer modulator platform' at the Spring Investor Conference, NYC, NY
   a. 2nd April 2019
   b. Spring Investor Summit (Microcap Conference)
   c. https://www.youtube.com/watch?v=Mn4oICQpVTQ
220) Invited video 'Lightwave Logic advancing its silicon photonic prototypes" by Proactive, (https://www.proactiveinvestors.com)NY
   a. 2nd April 2019
   b. Proactive video (Wall St) series: https://www.youtube.com/watch?v=3B0oGXvyogA
   c. Lightwave Logic, Inc. (OTCQX: LWLG) CEO Michael Lebby tells Proactive the Englewood, Colorado-based technology platform company is in discussions with large and small players within the telecommunications and data-communications space, including companies who are involved in the manufacturing routers.
221) Reviewer: (European Commission) for project InSiDe
   a. 29th Apr 2019
   b. European Commission, Brussels
   c. InSiDe is an EU project for PIC based technology in the medical field to monitor blood flow and artery stiffness in the human body using long wavelength lasers and silicon photonics. Hospital clinical trials will be conducted. It is a follow-on with more clinical trials from the initial CARDIS EU project.
   d. http://www.inside-h2020.eu
222) Invited video Interview by EPIC CTO Jose Pozo in EPIC's Photonics Industry Luminary video series.
   a. 28th Jan 2019 (at Photonics West conference in San Francisco)
   b. EPIC Trade Association, Europe
   c. https://www.youtube.com/watch?v=e_V4TeTSwaM
223) Invited video 'Global Markets and Trends' at the 3rd International Roadmap conference, Faunhofer HHI, Berlin Germany
   a. 16th June 2019
   b. PhotonDelta video PR team
   c. https://vimeo.com/341952732
224) Reviewer (European Commission) for pilot line PISCALE

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a. 11th Sept 2019
b. European Commission, Brussels
c. PISCALE is a pilot line that is focused on bringing to commercial market flexible organic display technologies in both panel and reel to reel formats.

225) Invited talk and abstract: ECOC International Symposium on Hybrid PICs entitled "Polymer modulators enable the next generation of speeds and low power in optical networks"
a. 22nd Sept 2019
b. International Symposium and workshop (WO5) on Hybrid PICs,
c. ECOC conference 2019, Dublin, Ireland
d. https://www.ecoc2019.org/workshop.html

226) Invited talk and abstract: "Polymer modulators with >50GHz performance for power consumption reduction at 400, 800, and 1600 Gbaud aggregated data-rates"
a. 24th Sept 2019
b. Market Focus Session, Photonics Integration and Digital Silicon Photonics,
c. ECOC 2019, Dublin, Ireland
d. https://www.ecocexhibition.com/visit/market-focus/market-focus-2019-timetable/

227) Video: Polymer modulators with >50GHz performance for power consumption reduction at 400, 800, and 1600 Gbaud aggregated datarates"
a. 24th Sept 2019
b. ECOC, Market Focus at the ECOC Exhibit, (Youtube: Michael Lebby ECOC 2019)
c. ECOC 2019, Dublin, Ireland

228) Chairman and moderator, Market Focus ECOC 2019 session: Service and Content Provider Optical Transmission
a. 24th Sept 2019
b. Market Focus Session #5, ECOC 2019, Dublin, Ireland
c. https://www.ecocexhibition.com/visit/market-focus/market-focus-2019-timetable/

229) Chairman and moderator, Market Focus ECOC 2019 session: Optical Network Agility/Software Defined Networks
a. 24th Sept 2019
b. Market Focus Session #7, ECOC 2019, Dublin, Ireland
c. https://www.ecocexhibition.com/visit/market-focus/market-focus-2019-timetable/

230) Reviewer (European Commission) for pilot line MIPHAB
a. 10th Dec 2019
b. European Commission, Brussels
c. MIPHAB is a pilot line that is focused on bringing to commercial market near infra-red devices and packaging for industrial, defense, military and high-volume applications.

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2020

231) Webinar: Wall Street resource
   a. 9th Jan 2020
   b. Lightwave Logic HQ facilities in Denver, Colorado
   c. A 30min recorded webinar answering questions on Lightwave Logic and its business plans, technology and plans for the future.

232) Invited video Interview by EPIC in EPIC's Photonics Industry video series on European funded pilot lines.
   a. 5th Feb 2020 (at Photonics West conference in San Francisco)
   b. EPIC Trade Association, Europe

233) Reviewer (European Commission) for pilot line InPULSE
   a. 19th Mar 2020
   b. European Commission, Brussels
   c. InPULSE is a pilot line that is focused on bringing to commercial market InP based photonic integrated circuits (PICs) for fiber communications, both datacom as well as telecom high-volume applications.

234) Keynote and Plenary speaker SPIE Photonics Europe International Conference
   a. Originally 31st March (then moved to 7th April 2020)
   b. Strasbourg, France (the plenary talk was completed using audio embedded powerpoint video remotely).
   c. The conference was held virtually in 2020 and the talk was attended by over 1000 attendees/visits.
   d. https://spie.org/profile/michael.lebby-4009?SSO=1

235) Chairman (elected) of ECOC Market Focus technical committee as part of the ECOC Exhibition.
   a. 10th May 2020
   b. Committee hosted and organized by ECOC Exhibition
   c. Market Focus Committee at: : https://www.ecocexhibition.com/visit/market-focus/

236) Invited speaker and presentation at Lightwave Logic Annual Shareholder meetings 2020 with Business Management Update, and presentation entitled, "Lightwave logic business review"
   a. 14th May 2020
   b. Presentation can be found at: https://drive.google.com/file/d/1xfisLKe6QIykCAIMjOZ0XdiR-Ht_O7zZ/view?usp=sharing
   c. Hosted by Lightwave Logic Inc. and MZ Group (Investor Relations)

237) Co-Chair (and summit host) of online summit for PIC International virtual session with live Q&A.
   a. 19th May 2020

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b. Hosted by Angel Tech (https://onlinesummit.angel-tech.net/breakout/pic-international)
c. Virtual conference with combination of pre-recorded presentations, live presentations, and live Q&A. Over 150 attendees.

238) Invited video clip on PIC technologies for online summit of PIC International conference.
a. 19th May 2020
b. Video clip (2:04) can be found at https://onlinesummit.angel-tech.net/breakout/pic-international
c. Summit host's introduction to the online summit PIC conference.

239) Invited speaker, EPIC 24hr Photonics World Tour virtual conference with talked entitled; "EO Polymers enable high speed and low power modulators at 1550nm and 1310nm."
a. 24th Jun 2020
b. EPIC 24hr Photonics World Tour final talk #72 and concluding remarks.
c. https://www.epic-assoc.com/24hours/ and video on Youtube at: https://www.youtube.com/watch?v=aiUSlfxP1z0 starting at 46:00

240) Invited paper/article entitled, "Electro-Optic Polymers Improve Speed and Power Efficiency" with co-authors Karen Liu and Cory Pecinovsky, Lightwave Logic Inc.
a. 5th Aug 2020
b. Published by Photonics Spectra magazine,
c. Hosted by photonics.com https://www.photonics.com/Articles/Electro-Optic_Polymers_Improve_Speed_and_Power/p5/vo180/i1193/a65902

241) Invited video interview, "2020 Market Focus and technology trends for ECOC 2020, Brussels, Belgium" as Chairman of ECOC 2020 Market Focus Technical Committee
a. 5th Aug 2020
b. Market Focus Exhibition for ECOC 2020,
c. Hosted by ECOC exhibition: https://www.ecocexhibition.com/visit/market-focus/

242) Chair and invited speaker, PIC International virtual conference on PICs: PIC Virtual II with presentation entitled; "Optical devices and industry roadmaps."
a. 2nd Nov 2020
b. PIC International Conference, (https://picmagazine.net/article/112351/AngelTech_Virtual_2_-_The_Sequel_Proves_A_Hit_Success) and (https://onlinesummit.angel-tech.net)

243) Invited speaker, EPIC Virtual Conference on Datacenters (in collaboration with EA and COBO) with presentation entitled; "Using polymer modulators to upgrade your PIC + Industry Roadmaps."
a. 4th Nov 2020
b. EPIC Trade Association and subsequent YouTube video (https://www.youtube.com/watch?v=tHh-z724D2g) and also at EPIC: https://www.epic-assoc.com/epic-online-technology-meeting-on-datacenter-interconnects-in-cooperation-with-cobo-and-ea/

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c. Hosted by EPIC
d. Hosted by CS International and PIC International (Angel Business, London)

244) Reviewer (European Commission) for pilot line PIX4LIFE
a. 2nd Dec 2020
b. European Commission, Brussels (virtual review)
c. PIX4LIFE is a pilot line that is focused on bringing to commercial market PIC dielectric solutions for applications in the visible wavelength range in the medical applications market.

2021

245) Invited speaker, EPIC Photonics Plus conference (virtual) with a talk entitled "Polymer Plus™: Upgrading your PIC with Ultrafast and Low Power Modulators."
a. 16th Feb 2021
b. EPIC Trade Association https://photonicsplus.com and also at EPIC: https://photonicsplus.com/exhibitors/
c. Hosted by EPIC

246) Invited speaker (updated virtual presentation), EPIC Photonics Plus conference (virtual) with a talk entitled "Commercializing Polymer Modulators."
a. 10th Mar 2021
b. EPIC Trade Association https://photonicsplus.com and also at https://www.lightwavelogic.com/presentation/video-presentation-commercializing-polymer-modulators/
c. Hosted by EPIC

247) Invited Webinar and panelist: Roth Capital Partners (https://www.roth.com/Page/Corporate-Access-Past-Conferences)
a. 17th Mar 2021
b. 33rd Annual Roth Conference
c. Financial investment conference for public company review. Panelist for answering questions by bankers, investment specialists, and fund managers on Lightwave Logic and its business plans, technology and plans for the future.

248) Invited white paper/article entitled, "Polymers for Fiber Optic Communications: What does the Integrated Photonics Roadmap Say" co-authors Michael Lebby and Karen Liu, Lightwave Logic Inc.
a. 24th Mar 2021
b. Published by Lightwave Logic Inc., (https://www.lightwavelogic.com/wp-content/uploads/sites/319/2021/03/WP_IPSR-Roadmap-Decoded.pdf)
c. Executive summary: The IPSR (Integrated Photonic Systems Roadmap), a recent broad collaboration that unified the efforts of multiple established photonics

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roadmap efforts, describes the key technology bottlenecks for a broad array of applications and most promising solutions to overcome them. This whitepaper highlights the portion of the roadmap specific to fiber optic communications and within that the implications for the role of electro-optic polymers. Key findings identify critical advances that will be needed over the next decade to support the growth of very high data rate applications. By the end of the decade, integration of electronics with photonics will be part of broad integrated platforms. Innovative materials technologies such as polymers can be useful to enhance integrated photonics platforms with the use of high- speed modulators and passive optical interconnects.

249) Reviewer (European Commission) for pilot line Phabulous
   a. 31st Mar 2021
   b. Via European Commission (virtual review)
   c. Phabulous is a pilot line that is focused on bringing to commercial market micro-optics and free-form optics technology. Focus is on SMEs, prototyping and small volume manufacturing.

250) Chair and invited speaker, PIC International virtual conference on PICs: PIC Virtual III with presentation entitled; "Integrated photonic roadmaps."
   a. 12th Apr 2021
   b. PIC International Conference, (https://picmagazine.net/article/112351/AngelTech_Virtual_2_-_The_Sequel_Proves_A_Hit_Success) and (https://onlinesummit.angel-tech.net)
   c. Hosted by CS International and PIC International (Angel Business, London)

251) Reviewer (European Commission) for pilot line InPULSE (also known as Jeppix)
   a. 23rd Apr 2021
   b. Via European Commission (virtual review)
   c. InPULSE is a pilot line that is focused on bringing to commercial market InP based photonic integrated circuits (PICs) for fiber communications, both datacom as well as telecom high-volume applications.

252) Invited speaker, EPIC Virtual Conference on PIC Packaging with presentation entitled; "Integrated photonics roadmaps: enabling high performance packaging."
   a. 26th Apr 2021
   b. EPIC Trade Association and subsequent YouTube video (https://www.youtube.com/watch?v=tHh-z724D2g) and also at EPIC: https://www.epic-assoc.com/epic-online-technology-meeting-on-pic-packaging/
   c. Hosted by EPIC

253) Invited conference and panelist: Oppenheimer 6th Annual Virtual Emerging Growth Conference (https://www.oppenheimer.com/events/2021/6th-annual-emerging-growth-conference.aspx)
   a. 11th May 2021
   b. Oppenheimer 6th Annual Virtual Emerging Growth Conference.
   c. Financial investment conference for public company review. Panelist for answering questions with a variety of bankers, investment specialists, and fund

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managers on Lightwave Logic and its business plans, technology and plans for the future.

254) Invited speaker and presentation at Lightwave Logic Annual Shareholder meetings 2021 with Business Management Update, and presentation entitled, "Lightwave logic business review"
   a. 27th May 2021
   b. Presentation can be found at: https://www.lightwavelogic.com/presentation/2021-asm-business-update-por-lightwave-logic-ceo-dr-michael-lebby/
   c. Hosted by Lightwave Logic Inc. and MZ Group (Investor Relations)

255) Keynote speaker for PITC opening ceremony with presentation entitled, "Photonic Integrated Circuits (PICs): Enabling our future…"
   a. 2nd June 2021
   b. Agenda at: https://brainporteindhoven.com/en/events/launch-photonics-integration-techology-center and presentation at: https://www.lightwavelogic.com/presentation/photonic-integration-technology-center-keynote/
   c. Hosted by PITC (Photonics Integrated Technology Center); Photon Delta, TNO, Eindhoven University, Twente University.

256) Invited speaker: LD Micro Invitational XI conference (virtual) with presentation entitled, "Lightwave Logic Investor Presentation"
   a. 10th June 2021
   b. Presentation at: https://api.mziq.com/mzfilemanager/v2/d/307dbc8b-e212-48ba-9968-8cef3f6b5188/8c054319-48a6-bd6b-2a0c-66e56f5f489f?origin=2
   c. Hosted by LD Micro NASDAQ: SRAX

257) Invited video interview: "2021 Market Focus and technology trends for ECOC 2021, Bordeaux, France" as Chairman of ECOC 2021 Market Focus Technical Committee
   a. 15th June 2021
   b. Market Focus Exhibition for ECOC 2021,
   c. Hosted by ECOC exhibition: https://www.ecocexhibition.com/visit/market-focus/

258) Invited speaker at HC Wainwright non-deal roadshow (virtual)
   a. 3rd and 4th August 2021
   b. Presentation of "Lightwave Logic investor presentation"
   c. Hosted by HC Wainwright Investment Bank

259) Invited speaker at Q3 Investor Summit (virtual)
   a. 17th and 18th August 2021
   b. Presentation of "Lightwave Logic investor presentation" and link: https://drive.google.com/file/d/1mH0bCzOd8UxtvN6FeR50KIP7moFsFhjJ/view?usp=sharing
   c. Hosted by Investor Summit (https://investorsummitgroup.com)

260) Invited speaker and video recording at HC Wainwright conference (virtual)
   a. 13-15th September 2021
   b. Presentation of "Lightwave Logic investor presentation"

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c. Hosted by HC Wainwright Investment Bank

261) Invited speaker and video interview at NASDAQ for 10th September 2021 marketing closing. Live interview at NASDAQ HQ in Times Square, NYC.
   a. 10th September 2021
   b. Live interview for TV networks of Lightwave Logic's aspirations.
   c. Hosted by NASDAQ at their TV studios: https://www.nasdaq.com/videos/lightwave-logic-inc.-rings-the-nasdaq-stock-market-opening-bell

262) Invited interview to close the week of trading at NASDAQ on 10th September, 2021 with live speech, and televised session. The closing was carried by CNBC, FOX, Bloomberg, BNN networks during the close session.
   a. 10th September, 2021
   b. Live interview for Lightwave Logic, and live market closing for NASDAQ
   c. Hosted by NASDAQ at their TV studios: https://youtu.be/8dmHC8MeF6E
   a. https://youtu.be/8dmHC8MeF6E

263) TV and video interview by TD Ameritrade in conjunction with the ringing of the closing bell at NASDAQ on 10th September, 2021
   a. 10th September 2021
   b. Live TV interview on TD Ameritrade at NASDAQ studios, Time Square, NYC
   c. Hosted by TD Ameritrade financial network; https://tdameritradenetwork.com/video/rB4A-HvPH-2Be9Hw1tYC0w

264) Session chairman: ECOC Market Focus technical committee as part of the ECOC Exhibition: sessions included PIC and Silicon Photonics, Optics in Cloud computing, optical transmission (SDN, network agility), Fiber Access, 5G, Cable, PON, FTTX, FTTC, Fiber to the room, New technologies and optical systems, New markets, and new packaging platforms.
   a. 13th September 2021
   b. Committee hosted and organized by ECOC Exhibition
   c. Market Focus Committee at: : https://www.ecocexhibition.com/visit/market-focus/

265) Invited video interview: "2021 Market Focus impact for ECOC 2021, Bordeaux, France" as Chairman of ECOC 2021 Market Focus Technical Committee at the conference by ECOC TV https://www.youtube.com/watch?v=VrFeSwqnWAk
   a. 13th September 2021
   b. Market Focus Exhibition for ECOC 2021,
   c. Hosted by ECOC exhibition: https://www.ecocexhibition.com/visit/market-focus/ with video at

266) Invited talk and abstract: "Advancing integrated photonics with elector-optic polymer modulators".
   a. 13th September 2021

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b. Market Focus Session, PIC and SiPH/Datacenters/Optics in cloud computing, https://www.ecocexhibition.com/visit/market-focus/market-focus-2021-session-details/
c. ECOC 2021, Bordeaux, France

267) Winner: Acceptance of glass trophy for ECOC Industry awards on behalf of Lightwave Logic in the optical integration category: https://www.ecocexhibition.com/visit/ecoc-exhibition-industry-awards/
a. 14th September 2021
b. Product Focus session, ECOC Exhibition Industry Award Winner Announcement
c. ECOC 2021, Bordeaux, France

268) Interview: ECOC Industry awards on behalf of Lightwave Logic in the optical integration category by ECOC TV
a. 14th September 2021
b. Product Focus session, ECOC Exhibition Industry Award Winner Announcement
c. ECOC 2021, Bordeaux, France

269) Video interview: PIC International Conference November 9-11, Brussels, Belgium
a. 24th September 2021
b. Overview of conference, technical sessions, and integrated photonics
c. PIC International, Brussels, Belgium as part of the online web portal presence.

270) Reviewer (European Commission) for pilot line InPULSE (also known as Jeppix)
a. 21st Sep 2021
b. Via European Commission (virtual review)
c. MedPhab is a pilot line that is focused on bringing to commercial market silicon photonics based technologies for medical applications. Demonstrator use-cases as prototype products have been selected for the validation of the pilot line technologies covering both *in-vivo* and *in-vitro* domains. The cases include: manufacturing a disposable plasmonic-fluidic sensors and a wearable PCI temperature sensor.
d. https://medphab.eu

271) Reviewer: (European Commission) for pilot line MIRPHAB
a. 28th Sep 2021
b. Via European Commission (virtual review)
c. MIRPHAB is a pilot line that is focused on bringing to commercial market infra-red wavelength modules and technologies based on quantum cascade lasers, MIR detectors, Antimonide based compound semiconductors and their associated packaging.
d. https://www.iaf.fraunhofer.de/en/research/research-areas/semiconductor-lasers/mirphab.html

272) Reviewer: (European Commission) for pilot line InPULSE (also known as Jeppix)
a. 1st Oct 2021
b. Via European Commission (virtual review)

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c. InPULSE is a pilot line that is focused on bringing to commercial market InP based photonic integrated circuits (PICs) for fiber communications, both datacom as well as telecom high-volume applications.
d. https://www.inpulse.jeppix.eu

273) Invited Video presentation: LD Micro Main Investor conference entitled "Investor Presentation for LD Micro"
a. 12th October 2021
b. For virtual attendees at the LD Micro conference in Los Angeles (Luxe Hotel), California
c. Invited video presentation for virtual audience at LD Micro main event in LA California: https://www.meetmax.com/sched/event_76871/conference_home.html
d. https://www.youtube.com/watch?v=JEvSV8qYGMA

274) Invited audio interview: LD Micro for BIZPOD (the Drill Down by Cory Johnson).
a. 12th October 2021
b. Located at LD Micro main in LA, California
c. BIZPOD audio interview as part of their start-up entrepreneur series: https://www.bizpod.net

275) Invited oral presentation: Includes Q&A for LD Micro Main Investor conference entitled "Investor Presentation for LD Micro"
a. 12th October 2021
b. For live in-person attendees at the LD Micro conference in Los Angeles (Luxe Hotel), California
c. Invited live presentation on Lightwave Logic technology and business plans for virtual audience at LD Micro main event in LA California: https://www.meetmax.com/sched/event_76871/conference_home.html
d. https://www.youtube.com/watch?v=JEvSV8qYGMA and https://me21.mysequire.com/recording?session_id=d354f581-6ab6-47d9-99de-d642c1c25d87

276) Invited Video presentation: Ladenburg Thalmann Virtual Technology Expo conference entitled "Investor Presentation for Ladenburg Thalmann virtual Technology Expo Investor Presentation"
a. Video-taped on 27th October 2021 for release on 18th November 2021
b. For virtual attendees at the Thalmann Virtual Technology Expo conference.
c. Invited video presentation for virtual audience at 2021 Ladenburg Thalmann Virtual Technology Expo: https://ladenburg21.mysequire.com
d. Presentation can be found at: https://ladenburg21.mysequire.com

277) Invited video: Chairmans introduction to the 5th PIC International Conference, www.picinternational.net,
a. 7th-10th November 2021
b. Conference hosted by Angel events.
c. Sheraton Airport Hotel, Brussels, Belgium.

278) Session Chairman: 2nd PIC Pilot Line Conference, , www.picinternational.net,

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a. 7th November 2021
b. Conference hosted by Angel events.
c. Sheraton Airport Hotel, Brussels, Belgium.

279) Keynote speaker: Includes presentation entitled, "PIC Pilot Lines: Competitive Positioning" as part of the of 2nd PIC Pilot Line Conference, , www.picinternational.net,
a. 7th November 2021
b. As of the conference hosted by Angel events.
c. Sheraton Airport Hotel, Brussels, Belgium.

280) Session chairman: 5th PIC International conference, www.picinternational.net
a. 8-10th November 2021
b. Conference hosted by Angel events together with CS International, SSI International, and PIC Pilot Line Conference.
c. Sheraton Airport Hotel, Brussels, Belgium.

281) Invited Panelist: For the panel entitled, "PICs for LIDAR" of 6th PIC International conference, www.picinternational.net
a. 8-10th November 2021
b. Conference hosted by Angel events together with CS International, SSI International, and PIC Pilot Line Conference.
c. Sheraton Airport Hotel, Brussels, Belgium.

282) Invited speaker: With presentation entitled, "Increasing power efficiency with electro-optic (EO) polymers" at the 5th PIC International conference, www.picinternational.net in the day 2 session, "PICs vision- evolution and revolution"
a. 8-10th November 2021
b. Conference hosted by Angel events together with CS International, SSI International, and PIC Pilot Line Conference.
c. Sheraton Airport Hotel, Brussels, Belgium.

283) Keynote speaker: For Macrotrends (http://arnaerteconomics.com/dagvandetips2020/) investor conference (https://vimeo.com/653240070) and talk entitled "Investor Presentation'
a. 12th November 2021
b. Conference hosted by Marcotrends with 200 in person attendees, and 3-500 online attendees.
c. Ghent, Belgium

284) Invited Live TV interview: Benzinga (Spencer Israel show).
a. TV interview on 7th Dec 2021 with youtube recording: https://www.youtube.com/watch?v=kS-7FVTNE2Y
b. Presentation can be found at: https://www.youtube.com/watch?v=kS-7FVTNE2Y and the Spencer Israel show/background at https://www.linkedin.com/in/spencer-israel-44b02b31/ and https://www.benzinga.com/author/spencer-israel

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285) Invited Live TV interview: Benzinga (Spencer Israel show).
   a. TV interview on 11th Feb 2022 with youtube recording: https://www.youtube.com/watch?v=jFiB9P3voUk
   b. Presentation can be found at: https://www.youtube.com/watch?v=jFiB9P3voUk and the Spencer Israel show/background at https://www.linkedin.com/in/spencer-israel-44b02b31/ and https://www.benzinga.com/author/spencer-israel

286) Invited Webinar and panelist: Roth Capital Partners at the 34th Annual Roth Dana Point Conference, (https://www.roth.com/Page/Corporate-Access-Past-Conferences) with Lightwave Logic investor presentation and meetings.
   a. 13-15th March 2022
   b. 34th Annual Roth Deer Valley Conference (invite only)
   c. Financial investment conference for public company review. Panelist for answering questions by bankers, investment specialists, and fund managers on Lightwave Logic and its business plans, technology and plans for the future.

287) Invited Article and Interview entitled: "Q&A: Electro-optic polymers herald a new age of ultra-fast communication." With Digital Journal (https://www.digitaljournal.com), and interviewer; Dr. Tim Sandle.
   a. Digital Journal interview and publication on 1st April 2022 in the Digital Journal.
   b. Article and interview can be found at: https://www.digitaljournal.com/tech-science/qa-electro-optic-polymers-herald-a-new-age-of-ultra-fast-communication/article

288) Invited Article entitled: "Electro-optic polymers allow faster, more efficient data transmission." With Broadband Communities (https://www.bbcmag.com)
   a. Published in Broadband Communities 13th April 2022.
   b. Article can be found at: https://www.bbcmag.com/pub/doc/BBC_Mar22_webFINAL.pdf

289) Invited video: Chairmans introduction to the 6th PIC International Conference, www.picinternational.net, recorded on 10th May 2022.
   a. 8th May 2022 to be published in May 2022 for the conference being held on 27-29th June 2022
   b. Conference hosted by Angel events.
   c. Sheraton Airport Hotel, Brussels, Belgium.

290) Invited speaker at Oppenheimer 7th Annual Emerging Growth Conference (virtual)
   a. 10th May 2022
   b. Presentation of "Lightwave Logic investor presentation"
   c. Hosted by Oppenheimer Investment Bank: https://www.meetmax.com/sched/event_80933/conference_invlogin.html?event_id=80933&username=LWLG&confirmation_number=MVRJ8BYW865 and https://www.oppenheimer.com/events/2022/7th-annual-emerging-growth-conference.aspx

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291) Invited interview: Authority Magazine: "The future of communication technology"
   a. 11th May 2022, and published 18th May 2022.
   b. Interview on the future of communications, hosted by https://medium.com/authority-magazine
   c. Interview with David Liu, Authority Magazine

292) Reviewer (European Commission) for pilot line InPULSE (also known as Jeppix)
   a. 17th May 2022
   b. Via European Commission (virtual review)
   c. InPULSE is a pilot line that is focused on bringing to commercial market InP based photonic integrated circuits (PICs) for fiber communications, both datacom as well as telecom high-volume applications.

293) Invited speaker and presentation at Lightwave Logic Annual Shareholder meetings 2022 with Business Management Update, and presentation entitled, "Lightwave logic CEO management review"
   a. 26th May 2022
   b. Presentation can be found at: https://www.lightwavelogic.com/presentation/2021-asm-business-update-por-lightwave-logic-ceo-dr-michael-lebby/ and stream-video at: https://viavid.webcasts.com/starthere.jsp?ei=1544482&tp_key=3c8d96d340
   c. Hosted by Lightwave Logic Inc. and MZ Group (Investor Relations)

294) Invited oral presentation: LD Micro 12th Annual LD Micro Invitational conference with presentation entitled, "Lightwave Logic"
   a. 7th June 2022
   b. Presentation Webcast can be found at: https://me21.mysequire.com/
   c. Hosted by LD Micro NASDAQ: SRAX and located at Four Seasons in Westlake Village, California on 7-8th June 2022.

295) Invited video presentation: LD Micro XII Annual Invitational conference, recorded on 25th May 2022 (https://ldinv12.sequireevents.com)
   a. 7th June 2022
   b. Presentation at: : https://me21.mysequire.com/
   c. Hosted by LD Micro NASDAQ: SRAX at the Four Seasons in Westlake Village, California on 7-8th June 2022.

296) Invited speaker and presentation at MIT IPSRI roadmap event with presentation entitled "Transceiver roadmap 2022".
   a. 10th June 2022
   b. Presentation can be found at: https://photonicsmanufacturing.org/how-get-involved
   c. and https://www.eventbrite.com/e/2022-spring-ipsr-i-roadmap-meeting-tickets-323380047427
   d. Hosted by IPRSI, MIT, and PhotonDelta world photonics roadmap

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297) Board member Optica's Corporate Engagement Council, with activities focusing on industrial membership, marketing, conferences, workshops, meetings etc., for the photonics community globally.
   a. 10th June 2022, election to the CEC (https://www.optica.org/en-us/about/leadership_and_volunteers/councils/councils/
   b. CEC listing: https://www.optica.org/en-us/about/leadership_and_volunteers/councils/councils/#Industry
   c. Optica (Optical Society of America – previous name)

298) Reviewer: European Commission HORIZON-CL4-2022-DIGITAL-EMERGING-01-38 (CSA): International cooperation in semiconductors
   a. 8th June 2022
   b. European Commission: Reviewing submitted technical and coordinated support actions for electronics and photonics proposals for Horizon 2022 evaluation calls and rate proposals to EU guidelines.
   c. CSA:http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

299) Reviewer: European Commission HORIZON-CL4-2022-DIGITAL-EMERGING-01-03: Advanced multi-sensing systems.
   a. 10th June 2022
   b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2022 evaluation calls and rate proposals to EU guidelines.
   c. RIA:http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

300) Invited live interview with Dan Loney, Wharton Business Daily Radio Station
   a. 15th June 2022
   b. Wharton Business Daily live radio interview. Subject: Lightwave Logic business and technology plans for growth: https://twitter.com/whartonbizdaily?lang=en
   c. Location: virtual recording at Lightwave Logic, Englewood, CO.

301) Invited speaker at Diamond Equity Research Emerging Growth Invitational Conference (virtual)
   a. 17th June 2022
   b. Presentation of "Lightwave Logic investor presentation"
   c. Hosted by Diamond Equity Research Bank: https://www.diamondequityresearch.com/conferences/ at Lightwave Logic, Englewood, Colorado.

302) Invited video interview: "2022 Market Focus impact for ECOC 2022, Basel, Switzerland" as Chairman of ECOC 2022 Market Focus Technical Committee at the conference by ECOC TV (link to be published)
   a. 17th June 2022
   b. Market Focus Exhibition, technical sessions and awards for ECOC 2022,
   c. Hosted by ECOC exhibition: https://www.ecocexhibition.com/ecoc-exhibition-2022/ and recorded virtually in San Francisco, CA.

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303) Invited interview: MicrocapDaily: "Microcapdaily Interviews Dr. Michael Lebby CEO of Lightwave Logic, Inc. (NASDAQ: LWLG) On Radical Innovation Needed to Keep the Internet Growing"
   a. 23rd June 2022
   b. Interview on the radical innovation needed for the internet and optical networking, hosted by https://microcapdaily.com/microcapdaily-interviews-dr-michael-lebby-ceo-of-lightwave-logic-inc-nasdaq-lwlg-on-radical-innovation-needed-to-keep-the-internet-growing-2/
   c. Interview with Boe Rimes, Microcap Daily

304) Session chairman: 7th PIC International conference, www.picinternational.net
   a. 28-29th June 2022
   b. Conference hosted by Angel events together with CS International and SSI International.
   c. Sheraton Airport Hotel, Brussels, Belgium.

305) Invited Panelist: For the panel entitled, "Optica Industry Panel: Hybrid Integration" of 6th PIC International conference, www.picinternational.net
   a. 28-29th June 2022
   b. Conference hosted by Angel events together with CS International, and SSI International.
   c. Sheraton Airport Hotel, Brussels, Belgium.

306) Invited speaker: With presentation entitled, "Enabling low power consumption optical networking using high speed, low power polymer modulators" at the 6th PIC International conference, www.picinternational.net in the day 2 session, "Optimizing the PIC architecture"
   a. 28-29th June 2022
   b. Conference hosted by Angel events together with CS International, and SSI International.
   c. Sheraton Airport Hotel, Brussels, Belgium.

307) Invited speaker: "Status of Lightwave Logic and electro-optic polymers" at the Cleydael Golf Club, Antwerp, Belgium (www.cleydael.be)
   a. 30th June 2022
   b. Meeting organized by Belgium and Dutch retail investors of Lightwave Logic Inc. (NASDAQ:LWLG)
   c. Location: Belgium

308) Invited Article for 7th PIC conference entitled, "PIC International proved to be a fantastic success" (https://angel-tech.net/marketing/2022/mailers/post-show/pic/)
   a. 7th July 2022
   b. Conference hosted by Angel events together with CS International, and SSI International.
   c. Sheraton Airport Hotel, Brussels, Belgium.

309) Invited Live TV interview: Benzinga All Access Fireside Chat (Zunaid Suleman show).

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a. TV interview on 22nd July 2022 with youtube recording: https://www.youtube.com/watch?v=TyKY9R8WT_U
b. Video interview can be found at: https://www.benzinga.com/markets/emerging-markets/22/07/28231018/lightwave-logic-the-company-with-a-proprietary-solution-to-make-transmitting-data-faster and the Zunaid Suleman show/background at https://www.benzinga.com/events/speakers/zunaid-suleman/
c. Location: Virtually recorded in Washington DC

310) Invited Live TV interview with SNN network show Planet MicroCap Podcast and host Robert Kraft: https://www.youtube.com/watch?v=zCD-hTKtkLg
a. 22nd July 2022
b. Hosted by SNN and Robert Kraft, and video interview can be found at: https://podcasts.apple.com/us/podcast/lightwave-logic-nasdaq-lwlg-designing-modulators-that/id1024217659?i=1000574742796
c. Location: Virtually recorded in Washington DC

311) Invited Live Radio interview with Bloomberg markets radio show and hosts Paul Sweeney and Matt Miller. Topic, "Lightwave Logic background, radical innovation, business plans, impact on the internet, and where will the industry go in 5years?" Link to radio interview: "Efficient Data Transmission (Audio)."
a. 9th August 2022
b. Hosted by Paul Sweeney and Matt Miller at Bloomberg Market Radio show https://www.bloombergradio.com/shows/bloomberg-markets-am/
c. Location: recorded at Lightwave Logic, Englewood, Colorado.

312) Invited video interview with Smart Photonics' "50 Leaders of change" to address where the internet is going from a technology, photonics, and optical networking system perspective. Filmed by London based TBD Media and can be found at: https://vimeo.com/tbdmediagroup/review/742996199/8dc9821c7a. with interview at 3:00-50.
a. 10th August 2022
b. Hosted and videoed by TBD Media hub on Bloomberg.com
c. Location: Filmed at Lightwave Logic HQ in Englewood, Colorado and released on 9th November 2022.

313) Invited talk: Jefferies Semiconductors, IT Hardware & Communications Infrastructure Summit
a. 29-31st August 2022
b. Hosted by Jefferies Investment Banking
c. Sofitel Hotel, Chicago, Illinois

314) Invited lecture – TU/e (University of Eindhoven, Netherlands); Electrical Engineering (Photonics); "Polymer Modulators"
a. 2nd September 2022
b. Hosted by Photonics Integrated Circuits team, Electrical Engineering, TU/e
c. TU/e (Eindhoven University), Eindhoven, Netherlands

315) Invited review PhD thesis and defense that included review of thesis, public questions for the candidate and ceremonial procession. Amir Abbas Kashi's thesis is

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entitled, “Electro-optic slot waveguide phase modulators on the InP membrane on silicon platform”
   a. 2nd September 2022
   b. Hosted by TU/e Electrical Engineering, integrated photonics department with co-reviewers including: Prof. J. Leuthold, Prof. K. Williams, and Prof Van der tol.
   c. TU/e (Eindhoven University), Eindhoven, Netherlands

316) Invited keynote talk as part of the ‘New Materials in PICs’ at “EPIC meeting on CMOS compatible integrated photonics at IMEC.” With link to website: https://epic-assoc.com/events/epic-meeting-on-cmos-compatible-integrated-photonics-at-imec/
   a. 7-8th September 2022 with the talk on the 8th September 2022
   b. Hosted by IMEC and EPIC photonics association. With EPIC photonics at: https://epic-assoc.com
   c. Location at Leuven, Belgium at IMEC 1 foundry.

317) Invited speaker: “Status of Lightwave Logic and electro-optic polymers for foundry applications” at the Cleydael Golf Club, Antwerp, Belgium (www.cleydael.be)
   a. 8th September 2022
   b. Meeting organized by Belgium and Dutch retail investors of Lightwave Logic Inc. (NASDAQ:LWLG)
   c. Location: Belgium

318) Invited talk at HW Wainwright conference called: ‘H.C. Wainwright 24th Annual Global Investment Conference’, with a talk entitled, “Lightwave Logic Investor Presentation” and link to website: https://journey.ct.events/hub/660eb381-b261-4d25-afae-35b654ed04c1 and https://hcwco.com
   a. 12 and 13th September 2022 (talk on 13th September 2022)
   b. Meeting organized by HC Wainwright Investment Banking (https://hcwco.com)
   c. Location: Lotte Palace Hotel, New York City, NY

319) Invited interview: Interviewed by Greg Bryan at Telegeography (https://www2.telegeography.com) Podcast which can be found at: https://telegeography.podbean.com/ as well as https://blog.telegeography.com/simply-illuminating-considering-the-future-of-optical-transport
   a. 16th September 2022
   b. Published by Telegeography Podcast and Greg Bryan on 27th September 2022
   c. Virtual interview

320) Invited review article: Subject was for EPIC on their CMOS-foundry workshop : https://epic-assoc.com/events/epic-meeting-on-cmos-compatible-integrated-photonics-at-imec/
   a. 13th September 2022
   b. Published by EPIC photonics association and associated media outlets
   c. Review written in NYC, 13th September 2022

321) Invited article: Ping! Zine technology insights and can be found at: https://www.pingzine.com/featured-article/the-radical-innovation-of-a-new-polymer-internet/
   a. 29th September 2022

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b. Published by Ping! Zine technology insights on 29th September 2022
c. Ping! Zine publishes in-depth content through authoritative contribution and thorough interviews with technology subject matter experts across multiple disciplines including cloud, data center, AI, big data, cybersecurity and more.

322) Session chairman: ECOC Market Focus technical committee as part of the ECOC Exhibition: sessions included PIC and Silicon Photonics, Optics in Cloud computing, optical transmission (SDN, network agility), Fiber Access, 5G, Cable, PON, FTTX, FTTC, Fiber to the room, new technologies and optical systems, new markets, and new packaging platforms.
a. 19-21st September 2022
b. Committee hosted and organized by ECOC Exhibition
c. Market Focus Committee at: : https://www.ecocexhibition.com/visit/market-focus/

323) Invited video interview: "2022 Market Focus impact for ECOC 2022, Basel, Switzerland," as Chairman of ECOC 2022 Market Focus Technical Committee at the conference by ECOC TV https://youtu.be/X8iQoB4vqaA
a. 20th September 2022
b. Market Focus Exhibition for ECOC 2022,
c. Hosted by ECOC exhibition: https://www.ecocexhibition.com/visit/market-focus/

324) Invited talk and abstract: "Utilizing foundries to scale hybrid electro-optic polymer modulators" with Dr. John Zyskind, VP Engineering, Lightwave Logic Inc: https://www.ecocexhibition.com/visit/market-focus/components-ics-pics-fiber/
a. 19th September 2022
b. Market Focus Session, PIC components https://www.ecocexhibition.com/visit/market-focus/market-focus-timetable-2022/
c. ECOC 2022, Basel, Switzerland

325) Interview, industry award chairman, and award presentation to Market Focus Industry Award winners: ECOC exhibition industry awards (in conjunction with optical connections magazine) https://www.ecocexhibition.com/visit/ecoc-exhibition-industry-awards/ :
a. 20th September 2022
b. Product Focus session, ECOC Exhibition Industry Award Winner Announcement
c. ECOC 2022, Basel, Switzerland

326) Market Focus Interview: ECOC TV on behalf of Lightwave Logic in the optical integration category by ECOC TV and can be found at: https://youtu.be/nRd3dYCozUM
a. 21st September 2022
b. Market Focus Session, PIC components https://www.ecocexhibition.com/visit/market-focus/market-focus-timetable-2022/
c. ECOC 2022, Basel, Switzerland

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327) Invited talk and panelist for ECOC Rump session, with talk entitled, "Hybrid Integration Roadmap: From pilot production to production in a semiconductor fab" at ECOC technical conference, chaired by Dr Jose Pozo, CTO Optica.
   a. 21st September 2022
   b. ECOC Rump session
   c. ECOC 2022, Basel, Switzerland

328) Paper (co-author): Post-deadline submission to ECOC 2022 entitled, "Thermally Stable Silicon-Organic Hybrid (SOH) Mach-Zehnder Modulator for 140 GBd PAM4 Transmission With Sub-1 v Drive Signals (Th3B.2) given by Carsten Eschenbaum, *Karlsruhe Inst Tech (KIT)* and SilOriX Gmbh.
   a. 22nd September 2022
   b. ECOC Post Deadline session 1; 13:42 to 13:54pm https://www.optica.org/events/topical_meetings/ecoc/schedule/?day=Thursday#Th3B.2
   c. ECOC 2022, Basel, Switzerland

329) Cited Acknowledgement for Post Deadline Paper: Post-deadline submission to ECOC 2022 entitled, ">500 GHz Bandwidth Graphene Photodetector Enabling Highest-Capacity Plasmonic-to-Plasmonic Links (Th3B.5) given by Stefan Koepfli, *Eidgenossische Technische Hochschule (ETH) Zurich*.
   a. 22nd September 2022
   b. ECOC Post Deadline session 1; 14:18 to 14:30pm https://www.optica.org/events/topical_meetings/ecoc/schedule/?day=Thursday#Th3B.5
   c. ECOC 2022, Basel, Switzerland

330) Invited presentation: Diamond Equity Research's annual Spotlight Emerging Growth Invitational Virtual Investor Conference, with a presentation entitled, "Lightwave Logic Investor Presentation" and can be found at https://us02web.zoom.us/webinar/register/WN_2aoRT-XPSZiCFd1cLkVrXA and https://finance.yahoo.com/news/diamond-equity-research-host-spotlight-113000297.html
   a. 4th October 2022 (10:20-10:50am East coast time)
   b. Diamond Equity Research's Spotlight Emerging Growth Invitational Virtual Investor Conference, conferences@diamondequityresearch.com
   c. Recorded 30th September 2022 virtually at LWLG.

331) Invited interview: Interviewed by Cory Johnson at The Drill Down podcast (https://twitter.com/drilldownpod?lang=en) Podcast which can be found at: https://www.iheart.com/podcast/269-the-drill-down-81530167/as well as https://twitter.com/DrillDownPod/status/1449964020522360836
   a. 7th October 2022
   b. Published by The Drill Down Podcast and Cory Johnson on 17th October 2022
   c. Virtual interview

332) Invited oral presentation: LD Micro Main Event XV conference with presentation entitled, "Lightwave Logic Update"
   a. 25th October 2022

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b. Oral presentation details can be found at: https://www.meetmax.com/sched/event_86249/conference_home.html as well as https://www.meetmax.com/sched/event_86249/conference_presentations.html?bank_access=0&event_id=86249
c. Hosted by LD Micro NASDAQ: SRAX

333) Invited video presentation: LD Micro Main Event XV conference, recorded on 25th October 2022
a. 25th October 2022
b. Presentation at: https://www.meetmax.com/sched/event_86249/conference_presentations.html?bank_access=0&event_id=86249
c. Hosted by LD Micro NASDAQ: SRAX at the Luxe Sunset Boulevard Hotel LA 24-26th October 2022

334) Invited closing comments: Optica Co-packaged and pluggable optics industry summit. Comments were on pluggables vs co-packaged integrated photonics solutions, roadmapping, and transceiver trends on data rate and low power consumption.
a. 25th and 26th October 2022
b. Details on the event can be found at: https://www.optica.org/en-us/events/industry_events/2022_optica_industry_summit/
c. Hosted by Optica (formally OSA) https://www.optica.org/en-us/home/ at Du Pont's innovation laboratories Sunnyvale, CA.

335) Invited speaker: Photonics Spectra Annual Conference with presentation entitled, "How electro-optic polymers boost PIC speed and power efficiency".
a. Recorded on 28th October 2022, for 9-11th January 2023
b. Details on the event can be found at: https://www.photonics.com/Advertise/MarketingBlog.aspx?AID=68312
c. Hosted by Photonics Spectra (www.photonics.com)

336) Invited talk at the Board meeting of Optica's Corporate Engagement Council. Presentation on focusing to increase industrial membership, improve marketing, optimize conferences and workshops for the industrial photonics community globally.((https://www.optica.org/en-us/about/leadership_and_volunteers/councils/councils/
a. 1st November 2022,
b. CEC listing: https://www.optica.org/en-us/about/leadership_and_volunteers/councils/councils/#Industry
c. Optica (Optical Society of America – previous name)

337) Invited interview with Laser Focus editor Peter Fretty, Editor in Chief of LASER FOCUS WORLD, on the subject of Lightwave Logic, and the radical innovation needed by the optical network and internet.
a. 3rd November 2022,
b. Laser Focus world can be found at: https://www.laserfocusworld.com and the magazine at: https://www.laserfocusworld.com/magazine
c. Laser Focus World

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338) Invited panel moderator at PIC Summit Conference, Eindhoven, Netherlands in conjunction with IPSR-I workshops. Panel entitled, "Heterogeneous Intergration: Electronics and Photonics united" with companies that included: IMEC, LionX, VTT, Ligentec, Corning, Smart Photonics, Fraunhofer HHI
   a. 7th November 2022
   b. PIC Summit Europe conference. https://www.picsummiteurope.com/program/
   c. Located at the High Tech Center, Eindhoven, Netherlands

339) Invited speaker at PIC Summit Conference, Eindhoven, Netherlands in conjunction with IPSR conference to summarize panel findings and discussion with audience.
   a. 7th November 2022
   b. PIC Summit Europe conference. https://www.picsummiteurope.com/program/
   c. Located at the High Tech Center, Eindhoven, Netherlands

340) Invited Speaker and chair of datacom group at the PIC Summit Europe Conference and IPSR-I workshops with sessions entitled, 'Paving the way to killer applications in 2035.'located at TU/e Eindhoven University, Netherlands. Workshop 1c: Datacom roadmap for 2023.
   a. 8th November 2022
   b. PIC Summit Europe conference and IPSR-I roadmap workshops. https://www.picsummiteurope.com/program/
   c. Located at the TU/e Eindhoven University, Netherlands.

341) Invited talk: IEEE IPC (Integrated Photonics Conference) https://ieee-ipc.org/industry-day/ as part of the conference https://ieee-ipc.org in the session Industry Day-Hot topics in industry. Talk entitled: "Enabling More Efficient Optical Networking using Ultra-high Speed, Ultra-low Power, Ultra-small Foundry based Polymer Modulators"
   a. 14th November 2022
   b. IEEE IPC IEEE IPC (Integrated Photonics Conference) https://ieee-ipc.org
   c. Located at the Hyatt Regency, Vancouver, BC, Canada.

342) Invited talk and panelist: IEEE IPC (Integrated Photonics Conference) https://ieee-ipc.org/industry-day/ as part of the conference https://ieee-ipc.org in the session Roundtable on Topics in Entrepreneurship. Talk entitled: "Entrepreneur or Intrapreneur" with company CEOs that included: OEwaves, Polariton, Freedom Photonics/Luminar, Aeponyx, Octane Wireless.
   a. 14th November 2022
   b. IEEE IPC IEEE IPC (Integrated Photonics Conference) https://ieee-ipc.org
   c. Located at the Hyatt Regency, Vancouver, BC, Canada.

343) Invited Video presentation: Ladenburg Thalmann Virtual Technology Expo conference 2022 entitled "Investor Presentation for Ladenburg Thalmann virtual Technology Expo Investor Presentation"
   a. Video-taped on 29th November 2022 for release on 7th December 2022
   b. For virtual attendees at the Thalmann Virtual Technology Expo conference 2022.

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c. Invited video presentation for virtual audience at 2022 Ladenburg Thalmann Virtual Technology Expo: https://ladenburgtech22.sequireevents.com/
d. Presentation can be found at: https://ladenburgtech22.sequireevents.com/

344) Invited panelist: Photonics Spectra panel (virtual and recorded) titled, "Scaling PIC-based applications to volume production." Panelists included representatives from Sicoya, Polariton, and Ligentec, and hosted by Dr. Jose Pozo, CTO Optica.
a. Recorded on 6th December 2022, for release 9-11th January 2023 (https://events.photonics.com/Event.aspx?EID=9&OC=EM)
b. Details on the event can be found at: https://www.photonics.com/Advertise/MarketingBlog.aspx?AID=68312
c. Hosted by Photonics Spectra (www.photonics.com)

345) Invited speaker at PhotonDelta's Delta Dialogues virtual interview entitled, "Heterogeneous Integration for PICs" on the summary and findings of PIC Summit Europe conference on Heterogeneous Integration that took place in November 2022. The session was chaired by Jorn Smeets, PhotonDelta.
a. 7th December 6, 2022
b. Details of the event can be found at www.photondelta.com and https://www.photondelta.com/events/ and https://www.photondelta.com/events/delta-dialogues-december-2022/
c. Hosted by PhotonDelta www.photondelta.com

346) Invited Panelist: Ladenburg Thalmann Virtual Technology Expo conference and presentation can be found at: https://ladenburgtech22.sequireevents.com/
a. 7th December 2022
b. For virtual attendees at the Thalmann Virtual Technology Expo conference 2022.
c. Invited investor presentation at 2022 Ladenburg Thalmann Virtual Technology Expo: https://ladenburgtech22.sequireevents.com/

347) Invited Webinar and panelist: Roth Capital Partners at the 11th Annual Roth Deer Valley Conference, (https://www.roth.com/Page/Corporate-Access-Past-Conferences) with Lightwave Logic investor presentation and meetings.
a. 14-16th December 2022
b. 11th Annual Roth Deer Valley Conference
c. Financial investment conference for public company review. Panelist for answering questions by bankers, investment specialists, and fund managers on Lightwave Logic and its business plans, technology and plans for the future.

348) Invited reviewer for European Commission program as part of the IPCEI (Important Project of Common European Interest) program on electronics and photonics.
a. Duration of review process Jun 2022 to Dec 2022
b. IPCEI (Important Project of Common European Interest) based on public funding.
c. IPCEIs are projects by the EU commission that have the potential to make important contributions to sustainable economic growth, jobs, competitiveness and resilience for industry and the economy in the Union as well as strengthen its open strategic autonomy, by enabling breakthrough innovation and infrastructure projects through cross-border cooperation and with positive spill-over effects on

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the internal market and the society as a whole. In particular, semiconductor power FETs, laser diodes, amplifiers, FET technologies using both compound semiconductors (GaAs, GaN, InP) as well as silicon semiconductors (Silicon, SiGe) were reviewed.

2023

349) Reviewer: (European Commission) for project InSiDe
   a. 24th Jan 2023
   b. Located at IMEC Ghent University facility, Ghent, Belgium
   c. InSiDe is an EU project for PIC based technology in the medical field to monitor blood flow and artery stiffness in the human body using long wavelength lasers and silicon photonics. Hospital clinical trials will be conducted. It is a follow-on with more clinical trials from an initial CARDIS EU project.
   d. http://www.inside-h2020.eu

350) Invited speaker and panelist for Laser Focus World Executive Forum (https://www.laserfocusworld.com/executive-forum) in San Francisco with talk entitled. "Hybrid integration with electro-optic polymers" and panel session entitled, "Enabling silicon photonics success"
   a. 30th January 2023
   b. Details of the event can be found at https://www.laserfocusworld.com/executive-forum and agenda at https://www.lfwexecutiveforum.com
   c. Panelists included: Jose Pozo, CTO Optica, David Piehler, Dell Technologies, Peter Winzer, Nubis Communications, Robert Blum, Intel

351) Interview with Benjamin Glick of Mergermarket magazine entitled, "Lightwave could acquire more assets ahead of commercialization—CEO"
   a. 3rd February 2023
   b. Details of the interview can be found at: https://community.ionanalytics.com/lightwave-could-acquire-more-assets-ahead-of-commercialization-ceo
   c. Video interview remotely from Lightwave Logic HQ in Englewood, Colorado.

352) Interview and podcast with Don Witt of Telecom Reseller's Channel Daily News for a podcast on Lightwave Logic: Background, radical innovation, technology, acquisitions, world record results, goals, and the future of optical networking in a decade. Podcast can be found at https://telecomreseller.com/2023/02/14/lightwave-logic-technology-enables-the-existing-fiber-internet-infrastructure-to-perform-3-times-faster-than-current-speeds-podcast/
   a. 8th February 2023 (interview) and published 14th February 2023
   b. Details can be found at: https://telecomreseller.com/category/channel-daily-news/
   c. Podcast is with Telecom Reseller which provides information on voice mail, audio/video conferencing and peripherals, association and industry news,

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services, applications, and related topics of daily importance to telecommunications professionals.

353) Invited Article entitled: "The Internet Is the Brick Wall Nostradamus Didn't See Coming" with sub-heading, "The road maps Lightwave Logic is creating for the future of photonics will guide people toward the focus areas and the technology challenges they can expect as performance demands increase." For the industry trends section of BBC magazine (Broadband Communities) at (https://www.bbcmag.com)
   a. Published in Broadband Communities 14th February 2023.
   b. Article can be found at: https://www.bbcmag.com/pub/doc/BBC_Jan23_BrickWall.pdf

354) Interview with AlphaStreet entitled, "Lightwave Logic will license technology to make its polymers ubiquitous: CEO Dr. Michael Lebby" Interview can be found at https://news.alphastreet.com/lightwave-logic-will-license-technology-to-make-its-polymers-ubiquitous-ceo-dr-michael-lebby/
   a. 6th March 2023 (interview) and published 10th March 2023
   b. Details can be found at: https://news.alphastreet.com/lightwave-logic-will-license-technology-to-make-its-polymers-ubiquitous-ceo-dr-michael-lebby/
   c. Interview is with AlphaStreet which provides financial information on companies and utilize NLP and AI techniques in the research industry.

355) Invited speaker: Roth Capital Partners 35th Annual Roth Conference (https://www.roth.com/Page/Corporate-Access-Past-Conferences)
   a. 13th Mar 2023
   b. 35th Annual Roth Conference (www.roth.com/oc2023)
   c. Financial investment conference for public company review. Panelist for answering questions by bankers, investment specialists, and fund managers on Lightwave Logic and its business plans, technology and plans for the future.

356) Interview with Laser Focus by Jose Pozo as part of his Industry Executive interviews for the photonics industry. Key topics included intrapreneur and entrepreneur experience, Lightwave Logic, photonics experience, OIDA, roadmapping, and key drivers for a career in photonics integration Interview can be found at: https://www.laserfocusworld.com/fiber-optics/article/14293915/how-thinking-ahead-shaped-the-fiberoptics-industry
   a. 16th March 2023 (interview) and published 17th May 2023
   b. Details can be found at: https://www.laserfocusworld.com
   c. Interview is with Laser Focus World which was originally published in 1965, as *Laser Focus World*—a monthly magazine for engineers, researchers, scientists, and technical professionals—provides comprehensive global coverage of optoelectronic technologies, applications, and markets. Nearly 70,000 qualified optoelectronics professionals from around the world currently subscribe.

357) Interview with IDC by Brandon Hoff on Lightwave Logic, background, radical innovation, proprietary electro-optic polymer technology, goals and why the company is planning on making polymers ubiquitous for the hyper-scaler, datacenter markets.

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a. 16th March 2023 (interview)
b. Details can be found at: https://www.idc.com
c. Interview is with IDC which provides market and financial information on the information technology and optical networking industry.

358) Invited article for ISE entitled " Proactive Powering Problem-Solving with Polymers" https://www.isemag.com/fttx-optical-networks/article/14290981/proactive-powering-problemsolving-with-polymers
a. 16th March 2023
b. Details can be found at: https://www.isemag.com
c. ISE has articles on IT solutions and education.

359) Invited article and interview (from panel discussion) at Laser Focus World Executive Forum (https://www.laserfocusworld.com/executive-forum) in San Francisco with article entitled, "Silicon photonics: Is it witchcraft? https://www.laserfocusworld.com/executive-forum/article/14290913/silicon-photonics-is-it-witchcraft
a. 17th March 2023
b. Details of the event can be found at https://www.laserfocusworld.com/executive-forum and agenda at https://www.lfwexecutiveforum.com, and article at: https://www.laserfocusworld.com/executive-forum/article/14290913/silicon-photonics-is-it-witchcraft, written by Sally Cole Johnson for Laser Focus.
c. Panelists included: Jose Pozo, CTO Optica, David Piehler, Dell Technologies, Peter Winzer, Nubis Communications, Robert Blum, Intel

360) Invited article for IMS expert insights entitled, "An Expert Witness Perspective on Inter Partes Review of Patents" by Dr. Michael Lebby, IMS Elite Expert, https://www.expertservices.com/insight/expert-witness-ipr-patents/
a. 12th April 2023
b. Details can be found at https://www.expertservices.com
c. Patent litigation cases can be won or lost through the actions and competency of an expert witness—making their role not only important but crucial. The article takes a closer look at the part an expert witness plays during the *inter partes* review and considers how the IPR process could be improved.

361) Invited interview with Semiconductor Engineering by Karen Heyman, in an article called https://semiengineering.com/transitioning-to-photonics/ entitled, "Transitioning to Photonics"
a. Interview taken on 4th April 2023 and published online 14th April 2023
b. Details can be found at: https://semiengineering.com/about-us/
c. The article is based on the premise that high speed and low heat make photonics technology essential, especially compared to electronics, but it's extremely complex, and talent is hard to find and train.

362) Session Co-chairman: 8th PIC International conference, www.picinternational.net
a. 17-18th April 2023 for 2 days of PIC sessions.
b. Conference hosted by Angel events together with CS International and Power Electronics International conferences.

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c. Sheraton Airport Hotel, Brussels, Belgium.

363) Chair Panel session: For the panel entitled, "Foundry models for PICs" of 8th PIC International conference, www.picinternational.net and moderated by Jose Pozo, CTO Optica. Panel members included Global Foundries, Tower, VTT
   a. 17th April 2022
   b. Conference hosted by Angel events together with CS International, and Power Electronics International conferences.
   c. Sheraton Airport Hotel, Brussels, Belgium.

364) Invited speaker and oral presentation: With presentation entitled, "Positioning electro-optic polymer modulators as an optical engine to extend data rate and low power performance for optical networking" at the 8th PIC International conference, www.picinternational.net in the day 2 session, "Scaling PICs in volume using foundries"
   a. 18th April 2023
   b. Conference hosted by Angel events together with CS International, and Power Electronics International conferences.
   c. Sheraton Airport Hotel, Brussels, Belgium.

365) Invited speaker: "Status of Lightwave Logic and electro-optic polymers" at the Cleydael Golf Club, Antwerp, Belgium (www.cleydael.be)
   a. 18th April 2023
   b. Meeting organized by Belgium and Dutch retail investors of Lightwave Logic Inc. (NASDAQ:LWLG)
   c. Location: Belgium

366) Invited interview with Semiconductor Engineering by Karen Heyman, in an article called https://semiengineering.com/new-standards-push-co-packaged-optics/entitled, "New standard push co-packaged optics"
   a. Interview taken on 4th April 2023 and published online 26th April 2023
   b. Details can be found at: https://semiengineering.com/about-us/
   c. The article is based on the premise that co-packaged optics (CPOs) promises five times the bandwidth of pluggable connections, however, the new architecture requires multiple changes to accommodate different applications, and if the design is efficient the optical engines will be able to impact both on-board optics as well as pluggable transceivers.

367) Invited speaker and oral presentation for the Sequire Investor Summit, San Juan, Puerto Rico. The presentation was entitled, "LWLG April 2023 investor presentation" with link https://puertorico.srax.com with agenda: https://schedule.puertorico.srax.com
   a. Conference on 25th and 26th April 2023 with presentation on 25th April 2023
   b. Link to website for Sequire event: https://puertorico.srax.com
   c. Investor conference at the La Concha hotel San Juan, Puerto Rico.

368) Invited speaker and oral presentation: Ladenburg Thalmann Technology Expo and conference 2023. The presentation was entitled, "LWLG April 2023 investor presentation" and can be found at: https://www.meetmax.com/sched/event_94169/__co-list_cp.html
   a. 27th April 2023

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b. The conference and expo 2023, was held at Convene Hotel, Park and 41st, New York, New York and can be found at: https://www.meetmax.com/sched/event_94169/__co-list_cp.html and also at https://www.ladenburg.com/investment-banking/ladenburg-thalmann-co-inc-
c. The 2023 Expo featured presentations from the managements of approximately 50-60 public and private technology companies covering Media and Content-Tech, Software and Service-Tech, and Hardware and Defend-Tech.

369) Invited article: 8th PIC International conference overview entitled, "An overview of Angeltech 2023 (PIC international conference)", which can be found at www.picinternational.net with newsletters@angelmail.co.uk
a. 2nd May 2023
b. Overview is based on the results of the PIC International Conference hosted by Angel events (17-18th April 2023) together with CS International and Power Electronics International conferences.
c. Sheraton Airport Hotel, Brussels, Belgium.

370) Invited speaker to chair Lightwave Logic Inc's Annual Shareholder Meeting (ASM) at the Inverness Hilton, Englewood, Colorado.
a. 25th May 2023
b. Lightwave logic Inc., Denver, Colorado.
c. Read script, chair voting procedures for Lightwave Logic Annual shareholder meeting for Lightwave Logic Inc.

371) Invited speaker for management/CEO presentation for Lightwave Logic Inc., at the Annual Shareholder Meeting (ASM) at the Inverness Hilton, Englewood, Colorado
a. 25th May 2023
b. Lightwave logic Inc., Denver, Colorado.
c. Annual shareholder meeting for Lightwave Logic Inc., with live presentation with live Q&A from investors.

372) Reviewer: European Commission HORIZON-CL4-2022-DIGITAL-EMERGING-Human-01-57 (Digital and emerging technologies for competitiveness and fit for the Green Deal), Horizon IA: Towards next generation of cost-effective multi and hyper spectral remote sensing systems, and applications to health, automotive, and waster sorting.
a. 10-26th May 2023
b. European Commission: Reviewing submitted technical photonics proposals for Horizon 2023 evaluation calls and rate proposals to EU guidelines.
c. IA:http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020

373) Invited keynote speaker at Safecapital investor conference in Ghent with talk entitled, "Commercializing electro-optic polymers" hosted by Brecht Arnaert, Chief Editor www.safecapital.eu with Safecapital Lente meeting, Vander Valk Hotel, Ghent.
a. 27th May 2023
b. Vander Valk Hotel, Ghent, Belgium
c. Safecapital organized a retail investor event with an invite for Lightwave Logic to present and network with investors: https://tixoom.app/brechtarnaert/ur0v1eff

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374) Invited interview with Stephen Hardy of Lightwave Online (www.lightwaveonline.com) with discussion entitled, "Lightwave Logic reaches electro-optic polymer materials commercialization with supply license agreement" and can be found at:https://www.lightwaveonline.com/optical-tech/components/article/14294661/lightwave-logic-reaches-electrooptic-polymer-materials-commercialization-with-supply-license-agreement?utm_source=LW+Friday+5&utm_medium=email&utm_campaign=CPS230602105&o_eid=9764C7112945F2S&rdx.ident%5Bpull%5D=omeda%7C9764C7112945F2S&oly_enc_id=9764C7112945F2S

a. Interview conducted on 30th May 2023, and published at www.lightwaveonline.com on 1st June in Stephen Hardy's Friday 5.

b. Article published at https://www.lightwaveonline.com

c. Lightwave online reports on activity in the fiber optics lightwave communications industry at https://www.lightwaveonline.com

375) Invited Live TV interview: Benzinga (Spencer Israel show).

a. TV interview on 9th June 2023 with youtube recording: https://www.youtube.com/watch?v=jFiB9P3voUk

b. Presentation can be found at: https://www.youtube.com/watch?v=jFiB9P3voUk and the Spencer Israel show/background at https://www.linkedin.com/in/spencer-israel-44b02b31/ and https://www.benzinga.com/author/spencer-israel/

376) Project advisor: European Commission HORIZON-CL4-2021-DIGITAL-EMERGING-01-07 LOLIPOP EU project number 101070441

a. 21st June 2023

b. European Commission

c. https://horizon-de-lolipop.eu

d. LOLIPOP: Lithium NiObate empowered siLIcon nitride Platform for fragmentation free OPeration in the visible and the NIR. Material technology includes LNOI (lithium niobate on insulator) and TFLN (thin film lithium niobate).

377) Contributing author: Heterogeneous Integration Roadmap (2023 edition), Chapter 17 Test Technology which can be found at: https://eps.ieee.org/images/files/HIR_2023/ch17_test.pdf

a. 9th August 2023

b. https://eps.ieee.org/technology/heterogeneous-integration-roadmap.html

c. Overview of the roadmap: The ITRS Assembly and Packaging Working Group has had many years of history of collaboration with the IEEE Societies in holding workshops and work sessions at IEEE Societies sponsored conferences and events around the world. The basis of this collaboration is the common shared interest in a Technology Roadmap for the IEEE Societies' membership, conference attendees and participants in the ITRS Technical Working Group work sessions. IEEE Societies Conferences are high profile forums on the latest research and development in Packaging, Interconnect, Test and the materials, processes and equipment supporting this R&D. The Roadmap workshops of the

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ITRS had provided an opportunity for the participants to review the directions of these technologies and build a technology Roadmap looking 15 years into the future.

378) Invited interview with the publication TWST (The Wall Street Transcript) and Erik Sherman, a reporter at (www.twst.com). The interview entitled "Interview with the Chairperson and CEO: Lightwave Logic Inc. (NASDAQ:LWLG)"
   a. Interview taken on 42nd August 2023 and published online 17th August 2023
   b. Details can be found at: (www.twst.com) and https://www.twst.com/interview/interview-with-the-chairperson-and-ceo-lightwave-logic-inc-nasdaqlwlg
   c. The Wall Street Transcript is a subscriber-based online and print publication for retail and institutional investors. For more than 50 years, it has published thousands of in-depth interviews with CEOs, industry analysts and professional money managers. The article is about Lightwave Logic and their market positioning for electro-optic polymer modulators in fiber optic communications.

379) Invited Live TV interview with Planet MicroCap Podcast and host Robert Kraft https://planetmicrocapshowcase.com as Chairman and CEO of Lightwave Logic Inc.
   a. Recorded 23rd August 2023 and went live at the conference 6th September 2023.
   b. Hosted by Robert Kraft with video interview can be found at the website https://planetmicrocapshowcase.com
   c. Location: Virtually recorded in Washington DC

380) Invited presentation entitled, "commercializing electro-optic polymers" with Q&A by host Robert Kraft for Vancouver conference by Planet MicroCap https://planetmicrocapshowcase.com
   a. 23rd August 2023 with presentation conveyed on 6th and 7th September 2023
   b. Hosted by Robert Kraft with video Q&A that can be found at the website https://planetmicrocapshowcase.com and https://planetmicrocapshowcase.com/page-1551
   c. Location: Virtually recorded in Washington DC for virtual viewing in Vancouver Canada.

381) Invited interview for the Denver Business Journal, reported by Cassidy Ritter. With title of article, "Englewood tech company making the internet faster expands lab to scale commercial arm: The CEO said high speed and low power are the internet's Achilles heels, but that his company's technology can address those concerns."
   a. 8th September 2023
   b. Web link: https://www.bizjournals.com/denver/news/2023/09/08/lightwave-logic-expands-lab-commerical-arm.html
   c. The Denver Business Journal reports on business activities in the Denver tech center region. https://www.bizjournals.com/denver/ Interview location at Lightwave Logic Headquarters in Englewood, Colorado.

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