

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MERCEDES-BENZ USA, LLC
Petitioner,

v.

YECHEZKAL EVAN SPERO
Patent Owner.

U.S. Patent No. 10,894,503

IPR Case No.: IPR2023-01026

SECOND DECLARATION OF MATTHEW A. TURK, Ph.D.

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List of Declaration Exhibits

Exhibit No.	Description
2001	Declaration of Matthew A. Turk, PhD
2002	Curriculum Vitae of Matthew A. Turk, PhD
2003	Best Practices and FAQs for Filing Requests for Reexamination Compliant with 37 CFR 1.510 and 1.915, PTAB, May 2010
2004	Intentionally left blank
2005	Intentionally left blank
2006	U.S. Published Patent Application US2003/0137849A1 to Alden, Prosecution History in the U.S. Patent and Trademark Office
2007-2039	Intentionally left blank
2040	
2041	Transcript of Deposition of Nikolaos Papanikolopoulos, Ph.D. <i>Mercedes Benz-USA, LLC v. Yechezkal Evan Spero</i> , taken on February 23, 2024 IPR2023-01039, IPR2023-01040
2042-2049	Intentionally left blank
2050	Jianzhong Jiao and Ben Wang, “Etendue Concern for Automotive Headlamp Using LEDs,” SPIE Proceedings Vol. 5187, (January 2004) (Available at https://www.spiedigitallibrary.org/conference-proceedings-of-spie/5187/0000/Etendue-concerns-for-automotive-headlamps-using-white-LEDs/10.1117/12.504363.short)
2051	Michael Bass, <i>Handbook of Optics</i> 3 RD Edition Volume II, (McGraw-Hill, 2010) (Available at https://www.worldcat.org/title/555545456)
2052	Ben Wang and Jianzhong Jiao “Studies for Headlamp Optical Design Using LEDs,” SAE Technical Paper Series 2004-01-0434, (March 2004) (Available at https://www.sae.org/publications/technical-papers/content/2004-01-0434/)

Exhibit No.	Description
2053	Ben Wang and Jianzhong Jiao “Optical Transform Limitations in Headlamp Photometric Performance,” SAE Technical Paper Series 2005-01-0861, (April 2005) (Available at https://www.sae.org/publications/technical-papers/content/2005-01-0861/)
2054	Intentionally left blank.
2055	Jianzhong Jiao and Ben Wang “High-Efficiency Reflector Optics for LED Forward Lighting,” SPIE Proceedings Vol. 6670, (September 2007) (Available at https://www.spiedigitallibrary.org/conference-proceedings-of-spie/6670/66700M/High-efficiency-reflector-optics-for-LED-automotive-forward-lighting/10.1117/12.730524.short)
2056	Navigant Consulting “Energy Saving Estimates of Light Emitting Diodes in Niche Lighting Applications” Building Technologies Program Office of Energy Efficiency and Renewable Energy U.S. Department of Energy (September 2008) (Available at Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications (Technical Report) OSTI.GOV.)
2057	Intentionally left blank
2058	Intentionally left blank
2059	Intentionally left blank
2060	Michael Bass, <i>Handbook of Optics</i> 3 RD Edition Volume V, (McGraw-Hill, 2010) (Available at https://www.worldcat.org/title/557121959 .)
2061	Texas Instruments/Digikey “How DLP Technology Works,” (Available at https://www.digikey.com/en/product-highlight/t/texas-instruments/dlp-technology .) (Accessed September 12, 2023.)

Exhibit No.	Description
2062	Texas Instruments “Introduction to +/- 12 Degree Orthogonal Digital Micromirror Devices (DMDs) (Available at https://www.ti.com/lit/an/dlpa008b/dlpa008b.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-ww&DCM=yes&distId=10) (Accessed September 12, 2023.)
2063	Surendra Gupte, Osama Masoud, Robert F. K. Martin, and Nikolaos P. Papanikolopoulos “Detection and Classification of Vehicles” IEEE Transactions on Intelligent Transportation Systems, Vol. 3, No. 1 (March 2002) (Available at https://ieeexplore.ieee.org/document/994794) (Accessed February 20, 2024)
2064	Intentionally left blank.
2065	Webster’s New Universal Unabridged Dictionary Deluxe 2 nd Edition excerpts, Simon and Schuster (1983)
2066	Transcript of Deposition of Nikolaos Papanikolopoulos, Ph.D. <i>Mercedes Benz-USA, LLC v. Yechezkal Evan Spero</i> , taken on March 26, 2024, IPR2023-01026, IPR2023-01027
2067	Transcript of Deposition of Nikolaos Papanikolopoulos, Ph.D. <i>Mercedes Benz-USA, LLC v. Yechezkal Evan Spero</i> , taken on March 27, 2024, IPR2023-01034

1. I, Matthew A. Turk, hereby declare as follows:

2. I am making this declaration at the request of Yechezkal Evan Spero in the matter of *Inter Partes* Review of U.S. Patent No. 10,894,503 (“the ’503 Patent”) to Yechezkal Evan Spero.

3. I previously prepared a declaration in this proceeding dated October 20, 2023, submitted as an exhibit (Ex. 2001) with a Patent Owner Preliminary Response of the ’503 Patent to a Petition filed on June 6, 2023 by Petitioner Mercedes Benz USA, LLC. I understand that the Board instituted the Petition on January 17, 2024.

4. For this second declaration, I have been asked to again provide opinions on the claims of the ’503 Patent in light of the prior art, Petitioner’s arguments in the Petition and the corresponding declaration and testimony of Dr. Papanikolopoulos. If called upon to do so, I would testify competently thereto. I supplement my prior declaration (Ex. 2001) with this additional declaration to do so.

5. As I indicated in my prior declaration, although I am being compensated for the time spent reviewing materials and performing my analysis of the technical issues relevant to this matter, my compensation in no way depends on the outcome of this proceeding.

6. In preparation of this declaration, I have studied the exhibits as listed

in the Exhibit List shown above in my report.

7. In forming the opinions expressed below, I have considered:
 - a. The documents listed above as well as additional patents and documents referenced herein;
 - b. The relevant legal standards, including the standard for obviousness provided in *KSR International Co. v. Teleflex, Inc.*, 550 U.S. 398 (2007), and any additional documents cited in the body of this declaration; and
 - c. My knowledge and experience based upon my work and study in this area as described below.

I. Qualifications and Professional Experience

8. I am a Professor and President of the Toyota Technological Institute at Chicago (TTIC) and an Emeritus Professor of the Department of Computer Science at the University of California, Santa Barbara. I have worked and studied in the field of computer vision since 1984, as well as related areas of image processing, pattern recognition, machine learning, and human-computer interaction. The field of computer vision is concerned with determining how computers can extract, analyze and understand information from images and video and has been applied to a wide variety of applications including automotive lighting and controls such as those used in automotive adaptive forward lighting

systems.

9. I received my doctorate degree in Media Arts and Sciences from the Massachusetts Institute of Technology (MIT) in 1991. My doctoral work was in the area of computer vision, specifically concerning automatic face recognition. I received my Master of Science degree in Electrical and Computer Engineering from Carnegie Mellon University in 1984. My Master's work was in the area of robot fine motion planning. I received my Bachelor of Science degree in Electrical Engineering from Virginia Tech (VPI&SU) in Blacksburg, Virginia in 1982, where my senior honors thesis was on image processing.

10. In 1991, I published the paper "Eigenfaces for Recognition," which I co-authored with my Ph.D. advisor, Dr. Alex Pentland. The research reported in this paper helped lead to practical automated face recognition systems that are used in today's security and surveillance systems, as well as in consumer applications. My work on Eigenfaces has received several awards, including an IEEE Computer Society Outstanding Paper award at the IEEE Conference on Computer Vision and Pattern Recognition (CVPR) in 1991 and a "Most Influential Paper of the Decade" award from the International Association for Pattern Recognition (IAPR) Workshop on Machine Vision Applications (MVA 2000).

11. Along with my co-authors, I have received several other awards at professional conferences and workshops for my work in computer vision, image

processing, and augmented reality, including several best paper awards and winning the ACM Multimedia Open Source Competition in 2015.

12. My industry experience includes working for Martin Marietta Denver Aerospace from 1984 to 1987, where I worked primarily on computer vision for autonomous vehicle navigation as part of the Defense Advanced Research Projects Agency's Autonomous Land Vehicle program, the precursor to the later DARPA Grand Challenge events and subsequent advances in self-driving automobiles. In 1992, I was a visiting researcher at LIFIA/ENSIMAG in Grenoble, France and from 1993 to 1994, I worked for Teleos Research in Palo Alto, CA; in both of those positions, I worked on computer vision methods for recognizing human faces, gestures, and activity. From 1994 to 2000, I was a researcher for Microsoft Research, where I was a founding member of the Vision Technology Research Group and conducted research in vision-based human computer interaction and other related areas.

13. In 2000, I joined the faculty of the University of California, Santa Barbara, as an Associate Professor. In 2005, I was promoted to Full Professor and served as the Chair of the Media Arts and Technology Graduate Program from 2005 to 2010. In 2017, I was appointed as Chair of the Department of Computer Science. At UCSB, I taught graduate and undergraduate courses related to computer vision, computer imaging, human computer interaction, probabilistic

models and methods, artificial intelligence, computer graphics, machine learning, and other areas. My graduate Computer Imaging course covered the fundamentals of imaging systems, including the capture, storage, display, retrieval, and processing of images, as well as the nature of light, color, optics, human vision, non-visible (UV and IR) and multispectral imaging, sensors, cameras, and illumination.

14. I co-founded (in 2003) and co-directed the Four Eyes Lab at UCSB, where the research focus is on the “four I’s” of Imaging, Interaction, and Innovative Interfaces. The Four Eyes Lab researches a variety of topics, including computer vision, pattern recognition, virtual and augmented reality, and face processing technologies such as face recognition and facial expression analysis. I worked on and supervised many research projects in these areas, including (1) visual recognition of automobiles and (2) multi-flash imaging, which used multiple image sources and special optics to infer 3D scene structure from images.

15. In 2014, I co-founded a startup company, Caugnate, to commercialize computer vision and augmented reality technology for remote collaboration. Caugnate was acquired by PTC Inc., in 2016, and now forms the core of the Vuforia Chalk augmented reality product.

16. In 2019, I became President of the Toyota Technological Institute at Chicago, an independent graduate research institute, where the research and

education focus of the faculty and Ph.D. students is on computer science theory, machine learning, artificial intelligence, and related areas such as computer vision, speech and language processing, robotics, and computational biology.

17. As a result of my work and research, I am a named inventor of U.S. Patent Number 5,164,992 entitled “Face Recognition System,” U.S. Patent Number 6,674,877 entitled “System and Method for Visually Tracking Occluded Objects in Real-time,” and U.S. Patent Number 9,495,761 entitled “Environment mapping with automatic motion model selection.”

18. I was a founding member of the Advisory Board for the International Conference on Multimodal Interfaces (ICMI), which provides a venue for disseminating recent advances in multimodal interaction research, systems, and methods, which includes combining visual modalities with audio, haptic, or other modalities. I served as the Chair of the ICMI Advisory Board from 2006 to 2009. I was also a founding member of the Advisory Board for the IEEE International Conference on Automatic Face and Gesture Recognition and served as the General Chair for the conference in 2011. I have been a primary organizer of several top research conferences, including serving as General Chair for the 2014 IEEE Conference on Computer Vision and Pattern Recognition, the primary annual conference in the field of computer vision, with over 2000 attendees, Program Chair for the 2017 IEEE Winter Conference on Applications of Computer Vision,

and General Chair of the 2019 International Conference on Multimodal Interfaces (ICMI).

19. I am currently an Associate Editor of the ACM Transactions on Intelligent and Interactive Systems and the International Journal of Computer Vision and Signal Processing, and was formerly an Associate Editor of Image and Vision Computing. I have also served as a guest editor of several other journals related to computer vision, machine learning, and facial recognition. I have published research on lighting and optics, including research focused on automobile-related imaging, including: “Car-Rec: A real-time car recognition system,” IEEE Workshop on Applications of Computer Vision (WACV 2011), January 2011; “VITS – a vision system for autonomous land vehicle navigation,” IEEE Trans. On Pattern Analysis and Machine Intelligence, Vol. 10, No. 3, pp. 342-361, May, 1988; “Video road-following for the Autonomous Land Vehicle,” Proc. IEEE International Conference on Robotics and Automation, Raleigh, N. C., April, 1987; “Color road segmentation and video obstacle detection,” Advances in Intelligent Robotic Systems: Mobile Robots, SPIE, Cambridge, MA, 1986.

20. I have also published research focused on “multi-flash imaging” – using optics, illumination, and computer vision techniques all together, including: “A projector-camera setup for geometry-invariant frequency demultiplexing,” IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2009),

Miami, FL, June 2009; “Characterizing the shadow space of camera-light pairs,” IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2008), Anchorage, Alaska, June 24-26, 2008; “Multi-flash stereopsis: depth edge preserving stereo with small baseline illumination,” IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 30, No. 1, pp. 147-159, January 2008; “Dealing with multi-scale depth changes and motion in depth edge detection,” Brazilian Symposium on Computer Graphics and Image Processing, October 2006. (Awarded “One of the Best Image Processing and Computer Vision Papers”); “Specular highlights detection and reduction with multi-flash photography,” Journal of the Brazilian Computer Society, Vol. 1, No. 12, pp. 35-42, 2006; “Efficient depth edge detection using structured light,” International Symposium on Visual Computing, Lake Tahoe, NV, December 5-7, 2005; “Discontinuity preserving stereo with small baseline multi-flash illumination,” International Conference on Computer Vision (ICCV'05), Beijing, China, 2005; “Harnessing real-world depth edges with multi-flash imaging,” IEEE Computer Graphics and Applications, Vol. 25, Issue 1, pp 32-38, January 2005; “Specular reflection reduction with multi-flash imaging,” Brazilian Symposium on Computer Graphics and Image Processing, pp. 316-323, Curitiba, PR, Brazil, October 2004; and “A non-photorealistic camera: depth edge detection and stylized rendering using multi-flash imaging,” ACM SIGGRAPH, Los Angeles, August 2004 (also ACM

Transactions on Graphics, Vol. 23, No. 3, pp. 676-685, August 2004.)

21. In 2020, I was elected a Fellow of the Association for Computing Machinery (ACM), the main professional society in the field of computer science, for “contributions to face recognition, computer vision, and multimodal interaction.” In 2013, I was elected as a Fellow of the IEEE (the Institute of Electrical and Electronics Engineers), an award conferred by the Board of Directors of the IEEE upon a person with an extraordinary record of accomplishments in any of the IEEE fields of interest. In 2014, I was elected as a Fellow of the International Association for Pattern Recognition (IAPR). In 2022, I was named as a Fellow of the Asia-Pacific Artificial Intelligence Association. In 2023, I was elected as a Fellow of the Artificial Intelligence Industry Alliance (AIIA). I am also the recipient of the 2011-2012 Fulbright-Nokia Distinguished Chair in Information and Communications Technologies. I have given many keynote presentations at top conferences and workshops in my fields.

22. I have provided my full background in the curriculum vitae that is attached as Exhibit 2002.

II. Relevant Legal Standards

23. I have been asked to provide opinions on the claims of the '503 Patent in light of the prior art.

24. It is my understanding that a claimed invention is unpatentable under

35 USC § 102 if a prior art reference teaches every element of the claim. Further, it is my understanding that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the alleged invention was made to a person having ordinary skill in the art to which the subject matter pertains. I also understand that an obviousness analysis takes into account factual inquiries including the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter.

25. It is my understanding that the Supreme Court has recognized several rationales for combining references or modifying a reference to show obviousness of the claimed subject matter. Some of these rationales include the following: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a known device to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and 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.

III. State of the Art as of 2002

A. POSA Considerations for LED Forward Lighting

26. While LEDs were being proposed for use in vehicle forward lighting applications to replace conventional light sources such as halogen and high-intensity discharge (HID) light sources, experts in vehicle lighting were uncertain, even years later in 2004 and beyond, if or when the significant challenges associated with use of LEDs in these applications could be overcome to meet government regulations and industry standards while satisfying vehicle design aesthetics and operational demands.

B. Regulations and Standards

27. As generally referenced in numerous vehicle forward lighting patents and publications, vehicle forward lighting is subject to various government and industry regulations. Regulations such as the Federal Motor Vehicle Safety Standards (FMVSS) in the U.S. specify requirements with respect to minimum/maximum intensity, color, and beam pattern and shape for specific types of vehicle lights, such as low beam headlamp beams (also referred to as the dipped beam or passing beam) and high beam headlamp beams (also referred to as main beam or driving beam), cornering lamp beams, fog lamp beams, and signaling lamp beams, for example. Considering the differing requirements, functions, and

positions for different types of lamp beams, a POSA would not have considered combining features from lamps having different functions (such as using amber color of fog lamp beams for low beam headlamps, or having high beam and low beam fog lamps, or cornering lamp beams having the intensity of low beam headlamps, etc.) or expect such combinations to meet regulatory requirements for a different type of lamp beam.

Any automotive headlamp beam pattern, either high-beam or low-beam, is a light luminous intensity (candela) angular distribution. The candela values are specified at different vertical and horizontal angles by using test points, lines, and zones. The specifications are governed by federal laws or industry recommendations. For a low-beam headlamp, for example, the beam pattern requirement is based on several factors: A) sufficient road illumination for driver visibility and safety; B) glare light control for the oncoming vehicle drivers; C) lamp aim-ability; and D) spread and foreground light for driver's comfort. Because of these requirements, the headlamp beam pattern must be a highly non-isotropic light distribution; and its light intensity varies in a range from a few hundreds to 20,000 or more candela.

(Ex. 2050¹ at 237.)

¹ Jianzhong Jiao and Ben Wang, "Etendue Concern for Automotive Headlamp Using LEDs", SPIE Proceedings Vol. 5187, published by the international society

Based on the recent development of white LEDs, it becomes feasible to design automotive headlamps using LED light sources. While these LEDs are reaching high lumen output, the uniqueness of headlamp applications has not yet been sufficiently addressed. This paper discusses the optical features of an automotive headlamp, its optical design principles, light intensity distribution and concentration requirements, and safety and customer pleasing needs.

(Ex. 2050 at 234.)

28. Regulations and standards define headlamp beam patterns so that light is provided to illuminate both near and far distances while avoiding glaring. The beam pattern includes invariable characteristics (such as a step, cutoff, and hotspot) that result from the optical system including the size, position, and intensity of the light source relative to reflectors and lenses to meet the photometric requirements at designated test points.

In certain angular area where high illumination is needed, the luminous intensity is very high and light is highly concentrated or collimated. This high light intensity area is called hotspot. At the top edge of the hotspot, light intensity is rapidly reduced to form a luminous intensity gradient or cutoff line, which serves two purposes: to control the glare light and to aim the lamp visually. Contrast to

for optics and photonics (January 2004). Ex. 2050 is a true and accurate copy of a technical paper that I understand was published by SPIE in January 2004.

hotspot, the light that spreads to left and right or foreground has much less intensity and a large diverge or spread angle instead.

(Ex. 2050 at 237.)

Cutoff is designed into the luminaire through the optics (i.e., edge-ray designs) and/or the integration of baffles. While most applications do not require cutoff classification, except for those used on the exterior, such as automotive, roadway, and landscape lighting, most designers include such to make effective lighting systems by alleviating potential glare, trespass, and pollution concerns. Often strict cutoff guidelines are mandated by governmental standards, such as for automotive, traffic signal, and roadway lighting. The goals are to provide the required lighting level to its users, while also alleviating light pollution and light trespass.

(Ex. 2051² at 40.43.)

A typical automotive headlamp is required to provide a specific output light distribution – beam pattern. For a low-beam headlamp, for example, the beam pattern requirement is based on several factors: (1) sufficient road illumination for driver visibility and safety; (2) glare light control for the oncoming vehicle drivers; (3) lamp aim-ability; and (4) spread and foreground light for driver's comfort. When the

² Michael Bass, *Handbook of Optics* 3RD Edition Volume II, (McGraw Hill 2010.)

Ex. 2051 is a true and accurate copy of excerpts of a book that I understand was published by McGraw Hill in 2010.

headlamp is constructed with multiple optical units or compartments with N LED light sources, each optical unit may have a different etendue value, or provide different luminous intensity and different spread angle.

* * *

However, because **both lamp aperture and number of LEDs that can be physically packaged into the lamp aperture are limited by vehicle level restriction**, the hotspot luminous intensity level, or performance is highly depending on the LED's luminance, rather than its total lumen output.

(Ex. 2052³ at 6,7, emphasis added.)

One major difficulty for forming a headlamp beam pattern is to obtain sufficient candela values in the hotspot while the lamp total aperture is limited. For high-beam design, it is more difficult to form the hotspot as its candela requirement can be as high as 40,000.

(Ex. 2050 at 237-238.)

The light intensity distribution or beam pattern from a forward lighting device is regulated by federal, state and international laws for

³ Ben Wang and Jianzhong Jiao, "Studies for Headlamp Optical Design Using LEDs", SAE Technical Paper Series 2004-01-0434, published by Society of Automotive Engineers (March 2004). Ex. 2052 is a true and accurate copy of a technical paper that I understand was published by SAE in March 2004.

safety. The optical system design to provide such beam patterns has been largely associated with the characteristics of the tungsten halogen or HID sources. White LEDs, on the other hand, have different optical characteristics, which in turn have impacted the headlamp optical system design.

(Ex. 2050 at 234.)

29. Regulations and standards require white light for vehicle forward lighting applications. As such, light sources emitting other colors are not available for use in increasing output light from vehicle headlamps.

Unless both covered and unlit, a vehicle operated on the highways of this state must not be equipped with a lamp or a part designed to be a reflector unless expressly required or permitted by this chapter or that meets the standards prescribed in 49 C.F.R. § 571.108. Except as otherwise provided, a lamp or a part designed to be a reflector, if visible from the front, must display or reflect a white or amber light; if visible from either side, must display or reflect an amber or red light; and if visible from the rear, must display or reflect a red light.

Michigan Vehicle Code Act 300 of 1949 § 257.698(4)⁴

⁴ Available at

[http://www.legislature.mi.gov/\(S\(3uenjar05mg4e4n3udxmh5on\)\)/mileg.aspx?page=GetObject&objectName=mcl-257-698](http://www.legislature.mi.gov/(S(3uenjar05mg4e4n3udxmh5on))/mileg.aspx?page=GetObject&objectName=mcl-257-698)

Generating white light from HB-LEDs is typically accomplished by one of two methods as depicted in Fig. 4. The first method, shown in Figs. 4a and b, utilizes an AlInGaN-LED in conjunction with one or more phosphors. When a UV-LED is used, the UV light emission is absorbed and re-emitted by a mixture of red, green, and blue phosphors.

* * *

The second method for white light emission is preferred when color tuning is necessary, such as in outdoor displays. As indicated in Fig. 4c, by using red, green, and blue LEDs, one can create white light when the appropriate ratio of each is selected. This RGB approach has the added benefit of allowing the user to create any color within the associated color gamut by balancing the ratio of the individual LEDs. This method also allows for active adjustment of the color temperature of white light emission which is not possible using the LED/phosphor approach.

(Ex. 2051 at 18.5.)

C. Design Tradeoffs

30. Design tradeoffs imposed significant constraints on the use of LEDs in vehicle forward lighting applications, particularly with respect to meeting the required intensity, color, beam pattern, optical efficiency, packaging size, and thermal/heat management requirements.

As shown in Fig.1, if one wants to obtain smaller spread angle to form a beam pattern, especially the hotspot of the beam pattern, the size of

optical unit needs to be enlarged, so that the reflection on the reflector can occur farther from the source to get smaller reflected light spread angle. However, the smaller focus length reflector leads to higher accuracy and tolerances, which is a big challenge for LED headlamp overall design.

(Ex. 2052 at 4.)

Besides the aperture, another limitation to form an adequate headlamp beam pattern is the overall size of the optical system and depth. Because of vehicle styling and packaging needs, the depth of a headlamp is also often restricted. As a consequence, the amount of lumen being collected and projected into the beam pattern through the optical system may not be sufficient to meet all the desires.

(Ex. 2050 at 238.)

Because of the limitations of lamp aperture, the optical system focal length, and the dimensions of the LED emitter, the total system efficiency is assumed $\eta = 0.42$, which includes reflection loss, transmitting loss, refracting loss and collecting loss (equivalent to the above tungsten halogen case).

(Ex. 2050 at 240.)

31. Years after the patent application filed by Spero, experts in vehicle forward lighting acknowledged that implementing LEDs in headlamps presented “great concerns and challenges for the optical engineers.”

With desires of high performance and compact packaging size for both high and low beams, the issues of using LED light sources

regarding light collection, efficiency, beam pattern compression and optical accuracy, are great concerns and challenges for the optical engineers.

(Ex. 2052 at 3, emphasis added.)

Besides the aperture, another limitation to form an adequate headlamp beam pattern is the overall size of the optical system and depth. Because of vehicle styling and packaging needs, the depth of a headlamp is also often restricted. As a consequence, the amount of lumen being collected and projected into the beam pattern through the optical system may not be sufficient to meet all the desires.

(Ex. 2050 at 238, emphasis added.)

32. In 2004 and beyond, multiple LEDs (more than 30) were required to generate lumen output similar to a typical tungsten filament halogen bulb as “currently available white LED’s lumen output [was] around 30 lm (maximum), which [was] about 3% of the typical tungsten halogen bulb’s light flux output (1000 lm for 9006 bulb).” (Ex. 2052 at 3.) Furthermore, “the luminance of LEDs must be comparable or higher than the existing tungsten halogen light sources.” (Ex. 2052 at 3.) The significant number of LEDs required to approximate a conventional halogen or HID light source would have prevented using those LEDs for purposes other than the designated low beam and high beam to satisfy regulations. Similarly, the large number of required LEDs would have prevented adding LEDs to perform forward lighting functions due at least to heat

management, cost, and packaging considerations described *infra*. Changing the position, size, number, or maximum output of a light source within a headlamp would require changing the optical system including reflectors and lenses to generate an output light beam meeting required standards or regulations.

When using a real light source such as LED with extended light emitting area A_s , light from the extended light source are diverged (or spread) by the optical system. The degree of the collimation depends on both the light source dimensions and the optical system characteristics such as focal length and aperture. If a light source size A_s with spread angle Ω_s ($2s$ is chosen, for a given lamp aperture A_{lamp} , smaller focal length leads to higher light collection efficiency, but less collimation (a dilemma we always have to face). In addition, in a reflector system, the degree of light collimation varies at different parts of the reflector aperture, while a lens system has consistent light collimation throughout the entire aperture.

(Ex. 2050 at 238.)

When multiple LED sources are used for one headlamp, each LED may have one FFR [Free Form Reflector] unit. The headlamp then consists of several FFR units. Because of the headlamp aperture and package limitations, small FFR unit with short focal lengths, e.g., approximately 10 mm may be used. Longer focal length **multiple LEDs headlamp may take too big of package space** and may not meet lamp size requirement.

(Ex. 2052 at 4, emphasis added.)

33. Even in 2004, it was unclear whether white LEDs would have sufficient light output to generate a light beam meeting applicable regulations and standards similar in intensity to conventional halogen sources.

Although total lumen flux produced by the LEDs may be comparable to the existing light sources, e.g., incandescent bulbs, the optical and mechanical characteristics of LEDs may limit the headlamp applications.

(Ex. 2052 at 3, Abstract.)

However, the currently available white LED's lumen output is around 30 lm (maximum), which is about 3% of the typical tungsten halogen bulb's light flux output (1000 lm for 9006 bulb). **If** the LED's output increases to 100 lm in the near future, it will be 10% of the tungsten halogen bulb's output. This **could lead to an assumption** that 10 LEDs with 100 lm output of each can be used to design an adequate tungsten halogen equivalent low-beam headlamp **if** the lamp system has the same light collection efficiency.

(Ex. 2052 at 3, emphasis added.)

Although the LED current application for headlamp design is limited, because of the flexibility of how to share aperture, it opens a great opportunity and challenge to optical engineers to develop the design concepts that are more efficient. Overall, our experiences have shown that with additional losses introduced by sharing aperture, more LEDs must be added to meet the headlamp beam pattern and total aperture needs. For instance, a headlamp package with approximately 15 LEDs

each has 100 lm output (again, total of 1,500 lm input) may be able to meet both performance and aperture requirements discussed in the above. However the total system efficiency is lower than tungsten halogen system.

(Ex. 2050 at 242.)

For designing an adequate (SAE) automotive headlamp low-beam, several design performance values are desired: A) total lumen within the required beam pattern is around 420 lm; B) hotspot candela value is around 25,000 cd; C) large spread angle, 1,000 cd reaches to 35° left and right. In order to achieve the low-beam performance (420 lm inside the beam pattern, and 25,000 cd in the hotspot), **it takes 50% larger effective aperture when using LEDs that have equivalent total lumen output as a tungsten halogen bulb.**

(Ex. 2052 at 7, emphasis added.)

Similar to the low-beam, for designing an automotive high-beam headlamp that meets the SAE photometry requirements, the desired lamp photometric performance is: A) total lumen within the required beam pattern approximately 600 lm; B) hotspot candela value around 50,000 cd; C) large spread angle with 2,000 cd at 15° left and right.

* * *

In order to achieve the high-beam performance (600 lm inside the beam pattern, and 50,000 cd in the hotspot), **it takes 150% larger effective aperture when using LEDs that have equivalent total lumen output as a tungsten halogen bulb** in aperture 8,000 mm².

(Ex. 2052 at 8, emphasis added.)

D. Hardware

34. Because light output from a single LED was insufficient to satisfy vehicle forward lighting regulations, multiple LEDs were needed. However, this presented challenges with respect to collecting and directing the light from an extended source as compared to a point source to generate the required beam pattern with corresponding luminance at designated points.

Because of the principle and the design restrictions for the system aperture and package size, the luminance of LEDs must be comparable or higher than the existing tungsten halogen light sources.

(Ex. 2052 at 3.)

The limitations or difficulties of using multiple LED to design headlamp may be summaries as two major parts: (A) as the total lamp aperture is being divided into several sub-apertures, the portion of the sub-apertures $A_{(lamp,i)}$ used for LEDs to project lights into hotspot zone with smaller spread angle $\Omega_{(lamp,i)}$ is small. **As a result, there may not be enough light for hotspot;** (B) the smaller sub-structure of the lamp has much smaller focal length comparing to tungsten halogen source, it then requires higher accuracy.

(Ex. 2052 at 10.)

One major difficulty for forming a headlamp beam pattern is to obtain sufficient candela values in the hotspot while the lamp total aperture is limited.

(Ex. 2050 at 237.)

E. Optical System

35. Headlamp optical system design requires a number of design considerations that may change depending on the type of light source being a conventional filament, a linear array of LEDs, a planar array of LEDs, etc. Selection and design of conventional geometric optics or free form reflectors (FFR), passive/active baffles, shields, deflectors, light sinks, modulators, imaging or non-imaging optics, position/focal points of extended array source including depth/distance between light source and reflectors and output lens(es), etc., all impact the resulting output light beam.

Although there are several typical optical systems to form a headlamp beam pattern such as reflector system, lens system, projector system, and others, the size of the effective aperture is essential for ensure the desired photometry performance.

(Ex. 2050 at 240.)

In order to maintain the system collection efficiency, one can shorten the focal length of the optical unit used for the LED source. However, smaller focal length system leads to larger light source images as well as higher system accuracy required. Both will be adding difficulties to the headlamp design and manufacturing.

(Ex. 2052 at 3.)

In both tungsten halogen and HID cases, the light emitting area is contained in small dimensions, and the light intensity distributions are in general, Lambertian. The light intensity distribution or beam pattern from a forward lighting device is regulated by federal, state and international laws for safety. The optical system design to provide such beam patterns has been largely associated with the characteristics of the tungsten halogen or HID sources. White LEDs, on the other hand, have different optical characteristics, which in turn have impacted the headlamp optical system design. In addition, the lumen output per LED is still much less than that the exiting tungsten halogen or HID sources provide, multiple LED sources must be used for one head lamp.

(Ex. 2050 at 234.)

[F]ive basic optical transforms used in the automotive lamp optical design have been discussed.

* * *

The limitations for these transforms are based on the etendue conservation. These limitations are the intrinsic properties of the optical systems used in the illumination applications including automotive lamps.

* * *

[T]he overall balance between the total lumen and luminance of the LEDs and the headlamp optical structure is controlled by these limitations.

* * *

[T]o achieve high performance for a headlamp, when the system losses caused by manufacturing . . . are not avoidable, sufficient lumen and luminance of the light sources and sufficient optical systems are always necessary and important.

(Ex. 2053⁵ at 10.)

In the design of the above prototype LED headlamp, because the plastic dome of the LED magnifies the chip image, each LED emitter then has effective size of 1.5 mm X 1.5 mm. As shown in the Fig. 11A & 11B, **the hotpots [sic] intensity of both low-beam and high-beam pattern are not high enough to provide sufficient down-the-road light.**

(Ex. 2052 at 10, emphasis added.)

When designing the low-beam headlamp using tungsten halogen bulb with FFR, the filament is in an axial orientation along the optical axis of the FFR. With such arrangement, it is quite natural to form the desired hotspot horizontal angular spread. Regardless what aspect

⁵ Ben Wang and Jianzhong Jiao “Optical Transform Limitations in Headlamp Photometric Performance”, SAE Technical Paper Series 2005-01-0861, published by Society of Automotive Engineers (April 2005). Ex. 2053 is a true and accurate copy of a technical paper that I understand was published by SAE in April 2005.

ratio or shape of the LED chip could be, it is important to realize that one of the chip demission must be small, or comparable to the size of the tungsten halogen filament diameter unless the LED emitter has extremely high luminance.

(Ex. 2052 at 11.)

F. Spatial Light Modulator

36. A POSA would have understood a spatial light modulator (SLM), to be an array of individually electrically controllable elements each operable as an optical switch. A transmissive SLM may be constructed using optical elements such as liquid crystals (LCs) that selectively transmit light in a first state (ON, for example) and selectively block light in a second state (OFF, for example). (Ex. 2060⁶, 8.29-8.30, pp. 342-343.) Alternatively, a reflective SLM, such as a digital light processor (DLP) used in projectors, may be constructed using optical elements such as micromirrors that reflect light at predetermined first/second angles depending on whether the switch is ON/OFF. (Ex. 2061⁷.) Light reflected at

⁶ Michael Bass, *Handbook of Optics* 3RD Edition Volume V, (McGraw-Hill, 2010.)

Ex. 2060 is a true and accurate copy of excerpts of a book that I understand was published by McGraw Hill in 2010.

⁷ Texas Instruments/Digikey “How DLP Technology Works.” Ex. 2061 is a true and accurate copy of a Digikey webpage (<https://www.digikey.com/en/product->

the first angle exits the device, while light reflected at the second angle is blocked by the device. (Ex. 2062⁸.)

37. An SLM is used to convert a light beam generated by a light source, such as an incandescent halogen bulb, for example, to multiple separate and individually controllable smaller light beams so that the smaller light beams can be individually blanked or blocked and do not exit the headlamp.

38. Intentionally left blank.

39. As would be recognized by a POSA, in view of the redundant functionality there is no reason to use an SLM in combination with individually controllable light sources such as LEDs for adaptive headlamp applications. On the contrary, for a POSA there are numerous reasons associated with cost and complexity that counsel against such a combination. For example:

highlight/t/texas-instruments/dlp-technology) that was accessed on September 12, 2023.

⁸ Texas Instruments “Introduction to +/- 12 Degree Orthogonal Digital Micromirror Devices (DMDs). Ex. 2062 is a true and accurate copy of a Texas Instruments Document that was revised in February 2018 and is available online at (<https://www.ti.com/lit/an/dlpa008b/dlpa008b.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-ww&DCM=yes&distId=10>) (Accessed September 12, 2023.)

- additional assembly and corresponding control complexity would be introduced in aligning positions of the LEDs within an array with corresponding SLM elements and determining which LEDs and SLM switches to control in combination;
- due to losses inherent to each optical element (SLM, lens, reflector, etc.) positioned in the path of a light beam, and the relatively low luminous flux generating ability of available LEDs at the time, light output from the LEDs would be further reduced by an SLM even while being operated in a transmitting state;
- use of an SLM to blank/block light being generated by one or more LEDs would result in increased power consumption and heat generation as compared to simply turning the corresponding LEDs off; and
- packaging considerations of placing a redundant device having multiple electrical connections with proper positioning relative to other optical elements of the headlamp, such as reflectors, lenses, etc.

40. For at least the reasons described herein, a POSA would not use an SLM in combination with a light source, such as an LED array, that already has the ability to individually control portions of the generated light beam to provide adaptive headlamp functionality because the functionality of the two components

is redundant, and thus unnecessary.

41. Intentionally left blank.

42. Intentionally left blank.

G. Heat management

43. The light output from an LED source varies with temperature and decreases as temperature increases. Similarly, the spectral characteristics or color of the light emitted by the LED varies with temperature. As such, heat management was an important consideration with respect to meeting regulations during operation of an LED headlamp. Furthermore, heat management imposed an additional design constraint such that POSAs were attempting to minimize the number of LEDs and/or maximize the efficiency of light output from the headlamp and would not be motivated to add LEDs to an array to provide additional functionality.

LED, in principle, is a temperature-dependent light source. In all cases, the higher the temperature, the lower the luminous flux output from LED is. As such, managing the heat generated in the LED, or heat from external environment of LED lamp, has been challenging because LED light output reduced when the temperature goes up.

(Ex. 2007, 50:2-9.)

When multiple chips are arranged linearly, such as 2 or 4 1mm x 1mm chips lined up inside of the LED package, if the current density of the

package is assumed the same for the above chip arrangement, higher temperature or high heat is generated for the LED packages with larger chip numbers. In practice, the heat dissipation may not be linearly related to the power of the LED packages, thus, due to the junction temperature dependence, the luminous flux of the LEDs is not linearly related to the chip numbers.

(Ex. 2055⁹ at 7.)

In recent years the push for solid-state white lighting has resulted in a transition to larger HB-LED chip sizes and an increase in the operating current densities. The latter brings new constraints to packaging due to the increased need for thermal management in an effort to keep the junction temperature of the HB-LED as low as possible. While the traditional packaging formats have proven very effective for standard drive current use, they are not suitable for high drive current applications using large area HB-LEDs since they do not provide adequate thermal management.

* * *

⁹ Jianzhong Jiao and Ben Wang “High-Efficiency Reflector Optics for LED Forward Lighting”, SPIE Proceedings Vol. 6670, published by the International Society for Optics and Photonics (September 2007). Ex. 2055 is a true and accurate copy of a technical paper that I understand was published by SPIE in September 2007.

Most HB-LEDs use sapphire substrates that provide very poor heat dissipation from the LED junction due to the low thermal conductivity of sapphire.

* * *

Standard clear epoxies that are used in conventional packages typically cannot withstand temperatures much above 100°C. In flip chip high drive packages this can be easily exceeded and would cause thermal damage to conventional epoxies.

(Ex. 2051, at 18.6.)

H. Packaging

44. Packaging considerations for automotive headlamps presented challenges even years after the earliest priority date of '551 Patent. These included the depth required based on longer focal lengths associated with LEDs, multiple LEDs required to achieve required light output at reduced collection efficiency due to extended array, sufficient heat sinks, driver electronics, and other components required for operation while meeting vehicle design aesthetic requirements.

One major difficulty for forming a headlamp beam pattern is to obtain sufficient candela values in the hotspot while the lamp total aperture is limited.

(Ex. 2050 at 237.)

With desires of high performance and compact packaging sizes for both high and low beam headlamps, using LED light sources is a great

challenge for the headlamp design optical engineers for light collecting efficiency, beam pattern compression and optical accuracy.

(Ex. 2052 at 3.)

Besides the aperture, another limitation to form an adequate headlamp beam pattern is the overall size of the optical system and depth. Because of vehicle styling and packaging needs, the depth of a headlamp is also often restricted. As a consequence, the amount of lumen being collected and projected into the beam pattern through the optical system may not be sufficient to meet all the desires.

(Ex. 2050 at 238.)

I. Cost

45. The higher cost associated with LEDs to provide similar illumination relative to conventional light sources such as halogen or HID sources was another factor that contributed to the uncertainty of whether LEDs were, even if feasible, a suitable replacement for conventional light sources in vehicle forward lighting applications.

[T]he added cost of solid-state white lighting has slowed the market acceptance. A common cost comparison is the first cost of a light source, typically measured in terms of the cost per kilolumen (klm). Incandescent and fluorescent light sources fall in the \$0.5 to \$3.00 per klm, while current light emitting diode sources fall easily in the \$20 to \$30 per klm range.

(Ex. 2051 at 18.5.)

[T]he LED light source can be more than 20 times as expensive as the incandescent light source it replaces.

(Ex. 2056¹⁰ at 66.)

J. Detection and Classification of Vehicles

46. Automotive adaptive forward lighting systems use various sensors and processing systems to detect and classify vehicles. In 2002, “magnetic loop detectors” were often used to detect or count vehicles passing over them. However, “Vision-based video monitoring systems offer a number of advantages” over such detection systems for example, “[i]n addition to vehicle counts, a much larger set of traffic parameters such as vehicle classifications, lane changes, etc., can be measured.” (Ex. 2063¹¹, 37.) Dr. Papanikolopoulos explained that “there has been

¹⁰ Ex. 2056 Navigant Consulting “Energy Saving Estimates of Light Emitting Diodes in Niche Lighting Applications” Building Technologies Program Office of Energy Efficiency and Renewable Energy U.S. Department of Energy (September 2008). Ex. 2056 is a true and accurate copy of a technical paper that I understand was published by the DOE in September 2008.

¹¹ Surendra Gupte, Osama Masoud, Robert F. K. Martin, and Nikolaos P. Papanikolopoulos, “Detection and Classification of Vehicles” IEEE Transactions on Intelligent Transportation Systems, Vol. 3, No. 1 (March 2002). Ex. 2063 is a

relatively little work done in the field of vehicle classification . . . because [it] is an inherently hard problem” due to, e.g., vehicles having different “shapes and sizes” and “occlusions, shadows, camera noise, changes in lighting and weather conditions” in “real-world traffic scenes.” (*Id.*)

47. Dr. Papanikolopoulos also explained that stereo cameras, e.g., cameras with two or more lenses with a separate image sensor or film frame for each lens, were unfeasible for real-time vehicle classification systems:

In addition, stereo cameras are rarely used for traffic monitoring. This makes the recovery of vehicle parameters—such as length, width, height etc., even more difficult given a single camera view. The inherent complexity of stereo algorithms and the need to solve the correspondence problem makes them unfeasible for real-time applications.

(*Id.*)

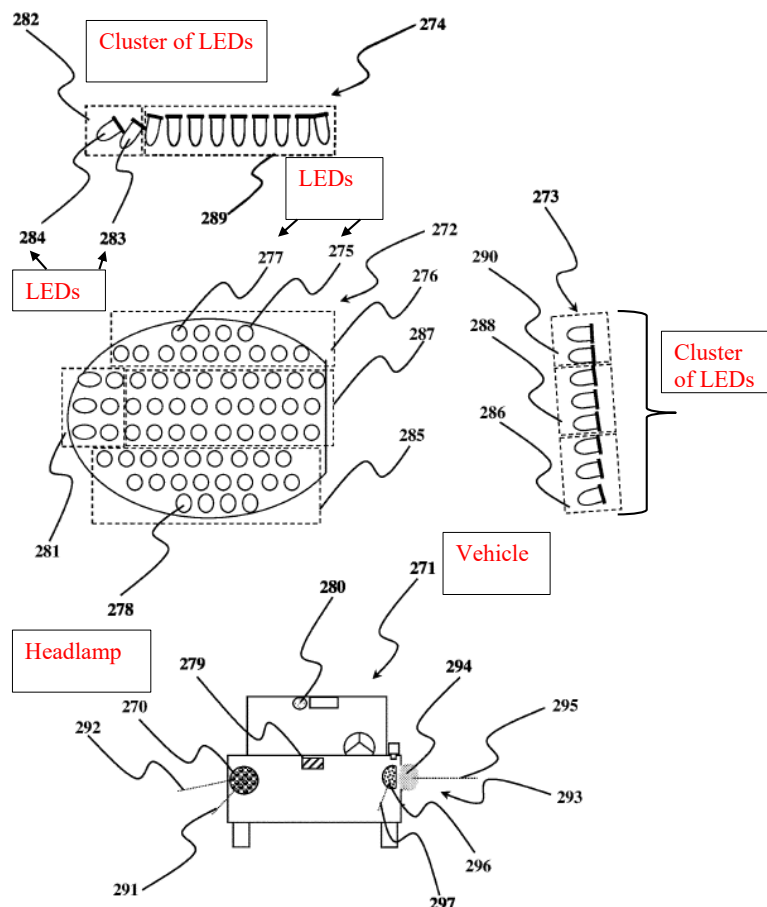
48. Accordingly, Dr. Papanikolopoulos proposed a system comprising six stages: 1) segmentation, 2) region tracking, 3) recovery of vehicle parameters, 4) vehicle identification, 5) vehicle tracking, and 6) vehicle classification. (*Id.* at 38.)

49. Intentionally left blank.

true and accurate copy of a technical paper that I understand was published by IEEE in March 2002.

IV. Overview of the '503 Patent

50. The '503 Patent is directed to “a novel multi-light source approach to the design and construction of solid-state lighting fixtures (vs. solid state lamps), which is termed a ‘Digital Lighting Fixture’, due to the control of individual lighting element ‘digits’ to provide the ‘correct’ lighting solution for the situation at hand.” (Ex. 1001, 11:11-16.) The '503 Patent further explains that “[t]he terminology ‘digital’ as used herein also refers to the discrete nature of the multiple LED lamps provided in the luminaire, whereby, ‘digital’ control results from the individual control of the discrete, i.e., ‘digital’ lighting elements, the LEDs, in the luminaire.” (*Id.*, 2:67-3:5.)



(Ex. 1001, Fig. 15, Annotated)

51. “The added controllability offered by breaking the total light output up into discrete (‘digital’) specifically aimable and dimmable elements which can be addressed by control electronics to effect intensity, spectrum and spatial distribution of intensity and spectrum, yields a lighting fixture (vs. lamp) of unparalleled performance.” (Ex. 1001, 11:61-67.) The ’503 Patent describes using a digital light fixture (DLF) to provide multiple functions, for example “[i]n a DLF it is possible to combine a task light having a very narrow ‘spot’ beam at the correct aiming with a general area lighting ‘flood’ beam into one fixture.” (*Id.*,

22:18-20.)

52. More specifically, the ‘503 Patent describes methods of using a multi-LED light source to segment a field of view and deliver varied, optimized illumination to the different segments within the field of view based on the presence of a detected object therein, “covering a wide scope of applications”, including transportation. (Ex. 1001, 11:18-21, 4:20-24, 50:40-41.)

53. In the context of headlights,

[a]dditional features can include an optional very narrow flashlight type of beam. . . Such a beam at the correct narrow aiming can continue to illuminate far ahead (in high beam) without blinding oncoming traffic. Analysis by a detector or an imaging system of the oncoming vehicles position (using its headlights for example) can be used to determine which exact aiming is the maximum allowable for any given traffic situation and road layout.

(Ex. 1001, 52:58-53:2.)

54. Additionally, a spatially differentiated illumination pattern can be determined to differently illuminate segments of a field of view based on the detection of an object:

Using color and pattern recognition techniques it is possible to determine what is a sign. It is then possible to provide the equivalent of “task lighting” and use the controller and properly aimed SLS to

follow and illuminate distant overhead and roadside signs for a longer time, yet not blind oncoming traffic due to the narrow beam.

(Ex. 1001, 53:3-8.)

55. The claimed invention of the ‘503 Patent is thus directed to multi-LED headlight systems that precisely determine anti-glaring illumination output to optimize illumination for the vehicle operator under a myriad of driving situations, whilst reducing glaring illumination for oncoming vehicles.

V. The Challenged Claims

56. The Challenged Claims are claims 1-36. Of those, claims 1, 20, and 26 are independent claims and are reproduced below. All other Challenged Claims depend directly or indirectly from one of those independent claims.

[1.P] A vehicle headlight system comprising:
[1.1] one or more headlamps and a vehicle structure, arranged for affixing components of the system to the vehicle;
[1.2] a plurality of light clusters, arranged in each of the one or more of the one or more headlamps,
[1.3] the headlamps capable of projecting light so as to illuminate a plurality of sub-sections of a field-of-view with different illumination characteristics,
[1.4] the subsections determined in response to sensor data, wherein the light clusters operate to create a headlight beam;

[1.5] electronic control circuitry configured to independently operate the light clusters;

[1.6] one or more sensors configured to obtain and provide the sensor data predefined as pertinent to illumination requirements for the field-of-view; and

[1.7] a logical controller including a processor, the processor in communication with a memory storing one or more algorithms, with the sensors, and with the control circuitry,

[1.8] wherein the processor is configured to process the one or more algorithms and the sensor data to determine an illumination for at least two of the sub-sections,

[1.9] that reduces illumination to reduce glare in at least a first of the at least two subsections and

[1.10] adapt the light emitted from one or more of the light-clusters so as to create the headlight beam that provides the determined illumination.

[20.P] A vehicle headlight system, comprising:

[20.1] one or more headlamps affixed to a vehicle,

[20.2] each headlamp including at least three directional light sources aimed

at different angles relative to the vehicle,
[20.3] the light sources configured to have one or more controllable light characteristics
[20.4] wherein a first light source of the more than one light sources at a first angle is less visually disturbing to traffic than a second light source of the more than one light sources aimed at a second angle, different from the first angle;
[20.5] control circuitry configured to adjust the at least one light characteristic of at least one of the directional light sources;
[20.6] one or more sensors configured to sense information
[20.7] defined as pertinent to determining illumination output from the one or more headlamps and
[20.8] communicating the sensed information to a processor as sensor data;
[20.9] the processor, in communication with at least the sensors and the control circuitry, configured to: process the sensor data to determine, within a field-of-view, at least a first subsection including a detected vehicle and
[20.10] at least a second subsection not including the detected vehicle,
[20.11] determine optimal use of the differently aimed directional light sources to maximize vehicle operator visibility in at least the second

subsection,
[20.12] while minimizing a disturbing effect, resulting from the illumination output, on the vision of other traffic in at least the first subsection, and
[20.13] direct the control circuitry to adjust the directional light sources to achieve the determined optimal use.
[26.P] A method for generating a headlight beam in an adaptive headlight system that provides illumination to at least a portion of a field-of-view, comprising:
[26.1] utilizing one or more sensors of a vehicle including the adaptive headlight system to obtain and provide data predefined as relevant to a determination of illumination requirements for the field-of-view, the data including data indicative of at least one of one or more other vehicles or a pedestrian;
[26.2] determining illumination requirements for the field-of-view based on the data sensed by the sensors, including determining illumination for at least a first subsection of the field-of-view including the other vehicle or pedestrian, as indicated by the sensor data, and for at least a second subsection of the field-of-view not including the other vehicle or pedestrian;

[26.3] determining a control strategy for controlling one or more directional light clusters in a headlight assembly to create an output headlight beam meeting the determined illumination requirements, the headlight beam spatial light distribution shaped to provide high beam illumination for a driver of the vehicle, in at least the second subsection, while mitigating glaring light illuminating at least the first subsection including detected other vehicles or pedestrians;

[26.4] sending control signals implementing the control strategy to an electronic control circuitry configured to operate the light-clusters; and;

[26.5] controlling the light clusters via the electronic control circuitry to collectively emit the headlight beam meeting the determined illumination requirements.

57. The dependent claims include additional innovative features that specify illumination strategies for a myriad of driving situations — for example, increasing illumination in a direction of the road curvature or a turn (claims 15-17), and, identifying vehicles or determining the position of vehicles (claims 7, 8, 11).

VI. Qualifications of One of Ordinary Skill in the Art

58. I have been asked to provide my opinion as to the level of skill of a person having ordinary skill in the art (“POSA”) of the ’503 Patent at the time of the claimed invention. In determining the characteristics of a hypothetical person

of ordinary skill in the art of the '503 Patent at the time of the claimed invention, I was told to consider several factors, including the type of problems encountered in the art, the solutions to those problems, the rapidity with which innovations are made in the field, the sophistication of the technology, and the education level of active workers in the field. I also placed myself back in the time frame of the claimed invention and considered the skill level of colleagues with whom I had worked at that time.

59. In my opinion a POSA for the invention claimed in the '503 Patent, would have had an undergraduate degree in mechanical engineering, electrical engineering, automotive engineering, optical engineering, applied physics, computer science, or a similar discipline, along with two years of experience working with intelligent vehicle systems, automotive control systems, or lighting control systems.

60. The more education one has, the less experience needed to attain an ordinary level of skill. Similarly, more experience in the field may serve as a substitute for formal education.

61. I understand that Petitioner has proposed the following level of ordinary skill:

A person of ordinary skill in the art ("POSITA") in the field of the '503 would have had an undergraduate degree in mechanical

engineering, electrical engineering, automotive engineering, optical engineering, applied physics, computer science, or similar disciplines, along with two years of experience working with intelligent vehicle systems, automotive control systems, or lighting control systems. (Papanikolopoulos Decl., ¶33.) The more education one has, the less experience needed to attain an ordinary level of skill. (*Id.*) Similarly, more experience in the field may serve as a substitute for formal education. (*Id.*)

(Petition, 8-9.)

62. I understand that the Patent Owner does not dispute Petitioner's proposed skill level for a person of ordinary skill in the art ("POSA"). (POR, 5.)

63. Intentionally left blank.

VII. Proposed Claim Construction

64. To properly evaluate these claims, I understand that the terms of the claims must first be construed. In my opinion, the claims of the '503 Patent do not include any terms that require specific construction. Instead, each of the claims includes terms that an ordinary artisan would understand according to their plain and ordinary meaning.

65. The plain meaning of a "turn" is a "change of direction when moving" (www.google.com/turn) while the plain meaning of a "curve" is a "continuously bending line, without angles." (<https://www.dictionary.com/browse/curve>). Thus, by their plain meanings alone, a "curve" lacks the "angle" that facilitates the

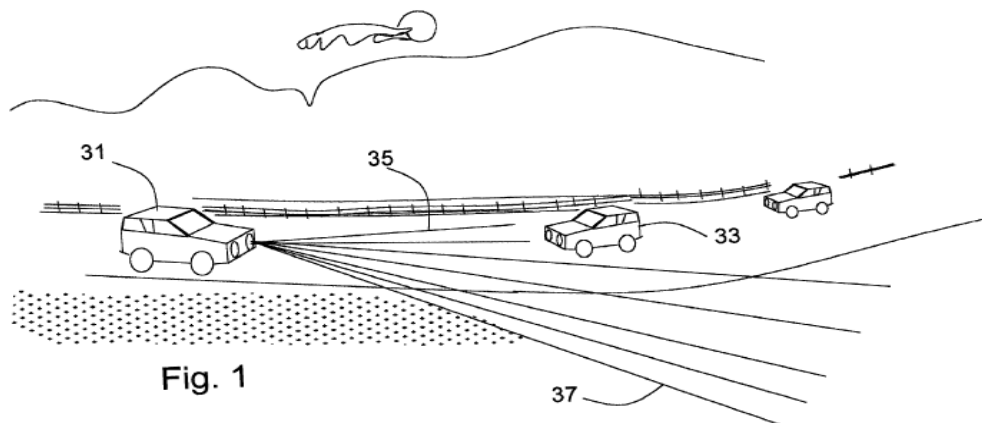
change of direction required for a “turn.” .

66. Intentionally left blank.

VIII. Overview of the Prior Art

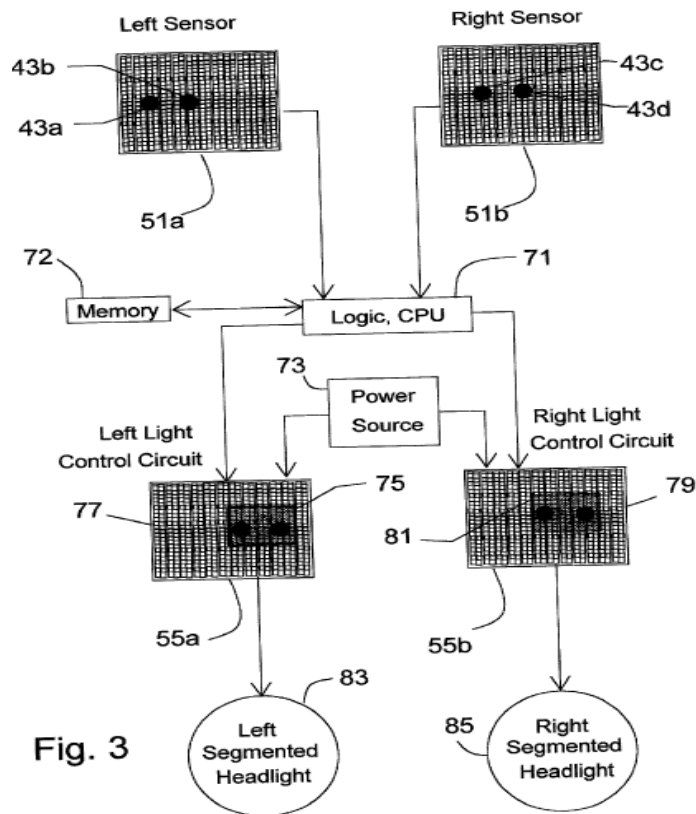
A. Alden

67. Alden is directed to controlling the distribution of light by a vehicle headlight. Alden’s systems include headlights that produce multiple individually controllable beam segments of light, each illuminating a sector of an area (“distribution area”) ahead of the vehicle equipped therewith (“equipped vehicle”). (Ex. 1005, ¶¶[0002, 0004-0006, 0008].)



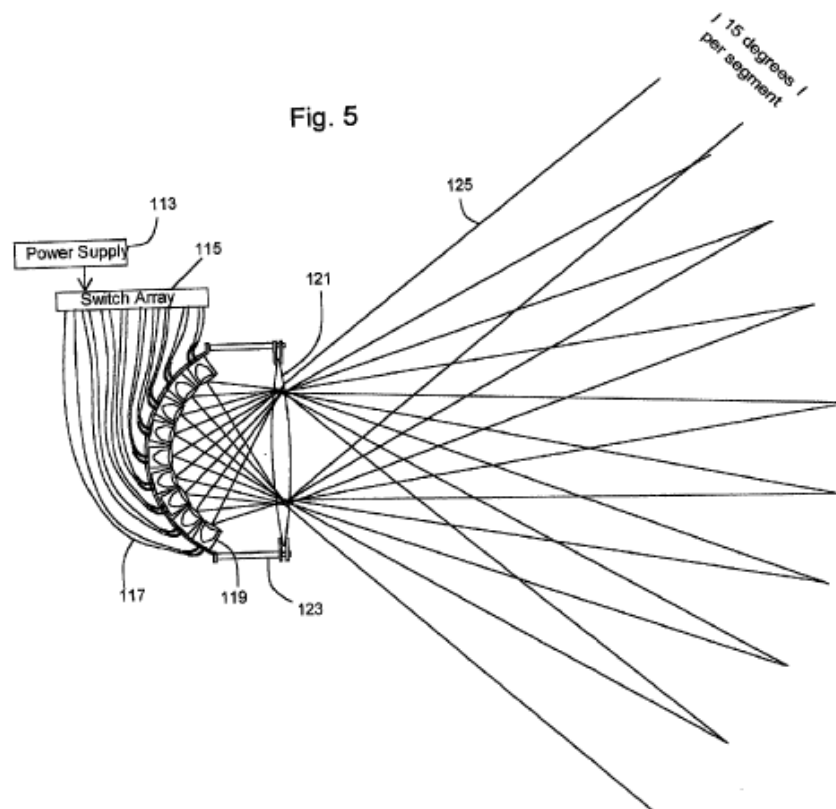
(EX. 1005, FIGURE 1)

68. The systems also include sensors 51a, 51b divided into multiple sectors for detecting incoming light. (Ex. 1005, ¶¶[0027-0028], Fig. 3-4.) Central processing unit (CPU) 71 determines whether incoming light detected in each sector of the sensors 51a, 51b has a threshold intensity. (*Id.*)



(Ex. 1005, FIGURE 3)

69. In the first of the three distinct embodiments, the headlight system sets LEDs of the headlight that have a relationship to one or more distribution area sectors. (Ex. 1005, ¶¶[0025-0026], [0029], Figures 1, 2, 5.) Per Figure 5, a headlight 123 employs a single-row array of light emitting diode (LED) elements 119 and a double convex lens 121. (*Id.*, ¶[0029].)

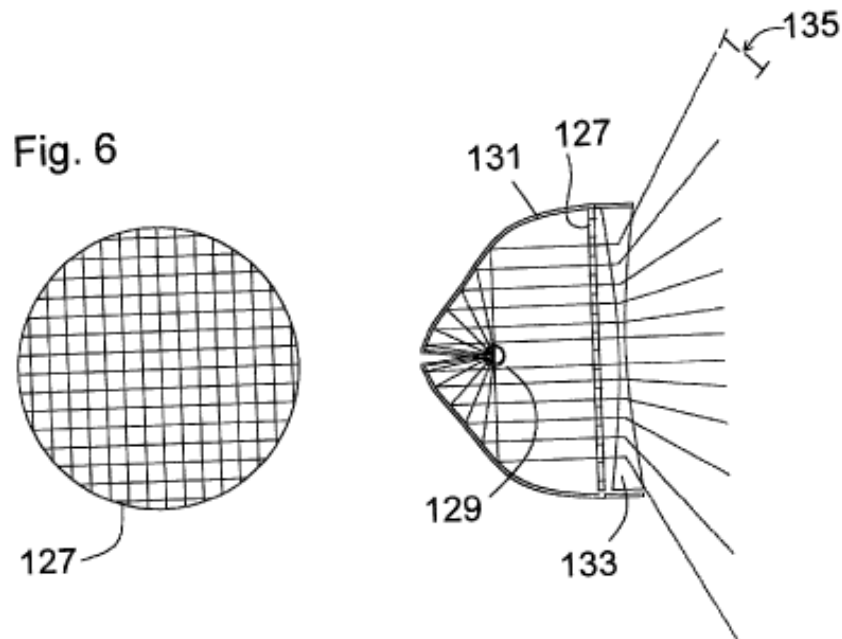


(Ex. 1005, FIGURE 5)

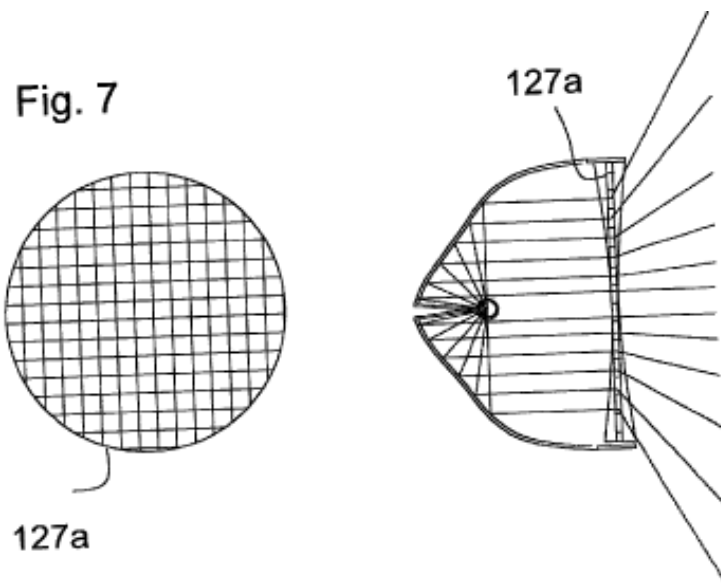
70. The CPU 71 may determine sectors of the sensors 51a, 51b receiving incoming threshold light, and then bounds a region encompassing the detected light. (*Id.*, ¶¶[0026-0029].) The bounding box is sent to the control switch arrays and switches encompassed by the bounding box limit power to corresponding headlamp elements (LEDs, in Figure 5.) (*Id.*, ¶[0029].)

71. In the second embodiment, a different headlight system shown in Figures 6 and 7, employs a single light source 129 and a collimating reflector 131 to produce collimated light which may be segmented using electro-chromatic dimming elements 127 that, in conjunction with a double concave lens 133, can

dim a given segment. (*Id.*, ¶[0030-0031], Figures 6, 7.) In Fig. 7 the electrochromic elements 127a are integrated within the double concave lens. (*Id.*, ¶[0031].)

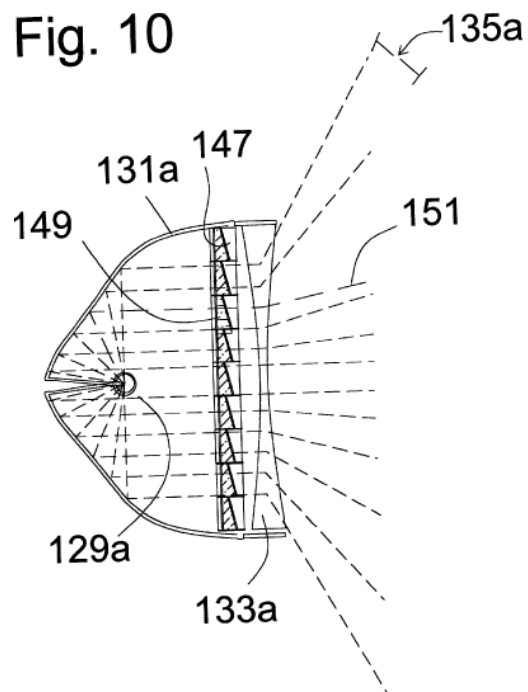


(Ex. 1005, FIGURE 6)



(Ex. 1005, FIGURE 7)

72. A third embodiment is shown in Figures 8-10, in which the headlight system employs a single light source 129, a collimating reflector 131, and electro-optic refractive elements 147, 149 to produce multiple light beam segments. (*Id.*, ¶¶[0032-0040].) The CPU 71 can control the electro-optic refractive elements 147, 149 to change the direction of the beam segments passing through respective elements. (*Id.*)



(Ex. 1005, FIGURE 10)

73. In this third embodiment, the electro-optical refractive material 147, 149 are bi-refringent liquid crystals, the principles of which Alden describes as

well known in the prior art. (*Id.*, ¶[0033].)¹² As seen in Figures 8 and 9, the birefringent liquid crystals can direct light in only two directions – straight and “bent” in one direction. (*Id.*, ¶[0050-0052].)

Fig. 8

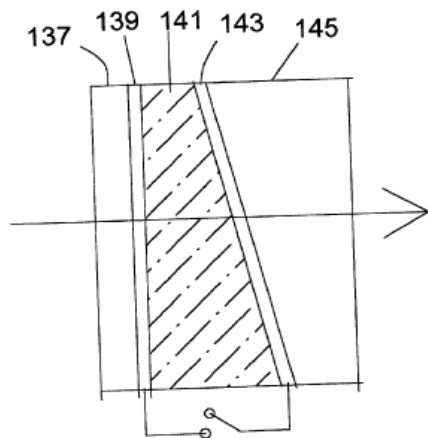
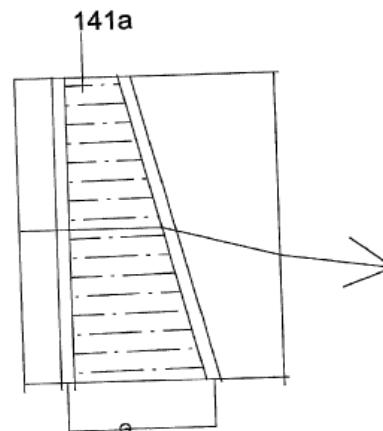


Fig. 9



(Ex. 1005, FIGURES 8, 9)

74. Regardless of whether implemented using a multiple LED light source as in the first embodiment or a single light source as in the second and third embodiments, all beam segments remain at high intensity unless specifically dimmed: “61 produces a high beam in a first sector 65 while concurrently producing a low beam in a second respective sector 63 (or dim beam) where the 41 is sensed ... Thus the driver of 47 can see everything illuminated to the

¹² Birefringent: “having the quality of birefringence”; Birefringence: “the power of double refraction.” (Ex. 2065, 186).

maximum.” (*Id.*, ¶¶[0006], [0026].) Alden further states in connection with Figure 3: “... segmented headlight 83 which distributes high beams throughout its distribution areas except in a box in the direction of 41.”¹³ (Ex. 1005, ¶[0027].)

75. Alden’s three embodiments are discrete and include features that are incompatible with each other. For example, the third embodiment of Figures 8-10 having electro-optical refractive material 147, 149 for changing the direction of light passing therethrough is designed to work with collimated light produced by single point light source 129 and collimating reflector 131. (Ex. 1005, ¶¶[0033-0035], Figs. 8-10.) However, in the first embodiment of Figure 5, the LED elements 119 of headlight 123 produce non-collimated light. Non-collimated light could not be directed in any meaningful fashion by electro-optical refractive material 147, 149 as shown in Figure 10. (Ex. 1005, ¶¶[0033-0035].) Rather, non-collimated light would blend and have different incident angles on the electro-optical refractive material 147, 149, thereby preventing the electro-optical refractive material 147, 149 from performing any meaningful control of beam segments, as well as redirecting much of the received non-collimated light away from the desired sectors of the distribution area. (*Id.*) Any headlight resulting from

¹³ Dr. Papanikolopoulos confirmed that this is one of the objectives of Alden’s system. (Ex. 2041, 50:9-12.)

a combination of Alden's incompatible features would therefore be incapable of meeting the basic requirements of a headlight, i.e., effectively illuminating the area ahead of the equipped vehicle, let alone directing its emitted light in any meaningful fashion. (*Id.*) Indeed, rather than suggesting combinations of various features of its different headlight system embodiments, Alden only states generally that each of its headlight system embodiments may employ the sensing elements 51a, 51b discussed in connection with Figures 3 and 4. (Ex. 1005, ¶¶[0044-0046].)

76. Intentionally left blank.

1. Alden's disclosure is theoretical

77. Alden's disclosure is theoretical in nature. The disclosure broadly describes certain features of headlight systems and the general functions such features and systems would desirably provide but lacks detailed explanations as to how those features and systems are practically implemented or how those functions are realized. As such, the reference is ambiguous on certain points and fails to enable its disclosure in critical respects. (*Id.*, ¶[0027-0035].)

78. I understand that Alden contacted Gentex Corporation, an automotive industry supplier, regarding his segmented headlight system and was informed that Gentex's technical staff had determined the system to be "futuristic" and likely "years away from any practical use." (Ex. 2006, 39.)

a. Dr. Papanikolopoulos's testimony does not

**clarify Alden's ambiguous teaching regarding
Embodiment 1**

79. I have reviewed Dr. Papanikolopoulos's deposition testimony (Exhibits 2041, 2066, and 2067) where he discussed Alden's disclosure as well as Petitioner's proposed modifications of Alden.

b. The LED Array of Figure 5

(1) Number of LEDs

80. Dr. Papanikolopoulos admitted that Alden disclosed nine LEDs in Figure 5 (Ex. 2066, 32:10-19) but in subsequent testimony declined to explain whether Alden disclosed any additional LEDs with reference to Figure 5, i.e., if the LED array included more than one row of LEDs.

Q: Okay. How many LEDs are disclosed in the headlamp that's shown in Figure 5?

A: Again, I want to tell you this is a high-end schematic and we see a slice. So I can count them, but it says the plurality of LEDs that they need to cover the whole field of view.

(Ex. 2041, 56:25-57:5.)

Q: So by that, are you saying there's more LEDs disclosed than what's shown in Figure 5?

A: What I'm saying is actually this is a schematic. So it just shows a concept, how this thing works.... the important part is actually you have a plurality of them...

(Ex. 2041, 57:12-21.)

Q: ... are you saying we're looking at one row of multiple rows...?

A: What's I'm saying is – actually this is one slice... it's going to be a second slice, a third...”

(Ex. 2041, 57:22-58:5.)

(2) Shape of LED Array

81. Dr. Papanikolopoulos stated that Alden provides a “very clear teaching” regarding the three-dimensional shape of the LED array. (Ex. 2066, 46:21.) During his first deposition, Dr. Papanikolopoulos described the 3-D shape of the LED array as having many variations, including a spherical shape:

Q: ... What is the shape of the LED array that's shown in Figure 5?

A: ... the 119 and other lighting elements are on a curve along the focal point...

(Ex. 2041, 114:11-15.)

Q: So if this is a section... what is below this section of light elements?

A: So they will be multiple – so think of stacks of this section that are going to form the – basically, the array of LED elements that corresponds to this control switch which is shown in Figure 3.

(Ex. 2041, 115:25-116:6.)

Q. All right. So if we can return back to the shape of LED array in figure 5, is there – if these are multiple stacks or multiple rows of

LEDs, would they be uniform in shape between one stack and an adjacent stack?

A. It can be many variations. I mean, you can have, for example -- I will give you an example. You can have an LED with a spherical cover that may give you more -- better visibility on the corner.

* * *

Q. Okay. So you mentioned that the LED array of Alden could be a spherical shape; is that correct?

A. Among other things. Again, it's a different design -- this may be different for a car that sits low like Porsche, for example.

(Ex. 2041, 119:9-17; 121:1-6.)

82. Dr. Papanikolopoulos was asked about the LED array shape again in his second deposition:

Q: . . . [C]an you answer yes or no? Does Alden describe another row of LEDs below the row illustrated in Figure 5?

* * *

A: **I don't think it is a yes or no answer** for the reasons that I explained.

(Ex. 2066, 45:6-11.)

83. Dr. Papanikolopoulos uses the phrase “slice” to describe the shape of structures shown in Alden’s figures. When asked to clarify what he means by “slice” he described it as the same as a section view:

Q. So when you say slice, is that like a section view?

A. Just like a planar view on a plane.

Q. Is that different than a section view?

A. If you assign -- if a POSITA assigns a section as a 2D section, it's the same thing.

(Ex. 2066, 10:15-19.)

84. A POSA would not have understood Alden's LED array to have a semispherical shape. If Figure 5 illustrates a section view, then the 3-D shape of the LED array is not semispherical. Accordingly, Dr. Papanikolopoulos agreed that it is "informative" to describe Alden's LED Array can be formed in a semicylindrical shape:

Q. So is it fair to describe the shape of the structure that these lighting elements are mounted on in Alden as semicylindrical?

A. I think it's informative

(Ex. 2066, 34:4-7.)

**(3) LED array shape corresponds to lens
121**

85. Dr. P. explained that the shape of the LED array corresponds to the shape of the lens 121:

Q: So if it's a very clear teaching, can you explain what the shape of this lighting structure is that's described with reference to Figure 5, as a shape?

A: So in other words, what is very clear here is that this is not – the LEDs are not on a flat surface. Why? Because this is not really the best way to direct light. So they are on a curve and as basically we move from slice to slice, the LEDs are placed closer to the lens or further away in order to capitalize on the focal point that is mentioned in this disclosure.

Q: So are you saying the slices of LEDs or rows of LEDs have different numbers of LEDs, different shapes?

A: What I'm saying is that the disclosure informs the POSITA, place the LEDs in a way that you maximize the collaboration, the cooperation between the LED elements and the lens, which means as you get different slices, you may want to place them closer to the lens or further away from the lens.

(Ex. 2066, 47:1-19.)

86. Dr. Papanikolopoulos described the shape of the lens 121 as biconvex and circular as viewed from the front:

Q. Okay, so the lens 121, you described it as a convex lens, would that be convex or biconvex lens?

A. It can be a biconvex. The objective is -- again, the importance of the disclosure here is actually how do we couple -- how a POSITA is informed to couple the characteristics of the lens with the placement of LEDs on this slice surface.

(Ex. 2066, 48:15-21.)

Q. So based on the mounting structure illustrated here, what is the shape of the lens illustrated in Figure 5 of Alden?

A. Maybe circular, for example. A POSITA will have heard that circular is -- is an option. But again, we have to consider that lenses are protected covers as well in headlights, so the material may have opaque properties or properties that maintains the perception. Okay, the perception of circular or not is not really what is important here. For a POSITA the importance is actually the placement of LEDs in conjunction with the lens along with the logic described in paragraphs 27, 28 and Figures 3 and 4 and . . . as a general overview, Figure 2.—

(Ex. 2066, 50:18-51:9.)

87. However, after Dr. Papanikolopoulos described the lens 121 as a biconvex lens that is formed in a circular shape as viewed from the front, he decided that the shape of the lens was not relevant to the shape of the LED array:

Q. Okay, so if the shape of the lens is circular in shape when looking at it from a front view, what would the corresponding shape of the structure holding lighting elements 119 look like?

A. A POSITA will have understood that what we see from the front view of the lens is not relevant in this -- in answering your question. A POSITA finds all the information they need by reading this statement that the 119 and the other light elements are on a curve along the focal point of a headlight lens 121. So such that the light from its light elements goes into a specified portion or portion of the headlight distribution area. In other words, if I don't -- if I put -- if the POSITA

puts them on a – something different than a curve, for example, on flat surface, then it's not the most effective implementation of this segmented headlight means.

(Ex. 2066, 52:4-20.)

(4) Shape corresponds to Figure 3

88. Dr. Papanikolopoulos describes each LED as being controlled by a control switch of Figure 3:

Q: So what would be the three-dimensional shape of this array that's shown in Figure 5?

A: ... it's going to be something that corresponds to... the figure 3 that we have, which is an array matrix of LED elements, each one controlled by each control switch that corresponds to the particular location coordinate where light has been detected.

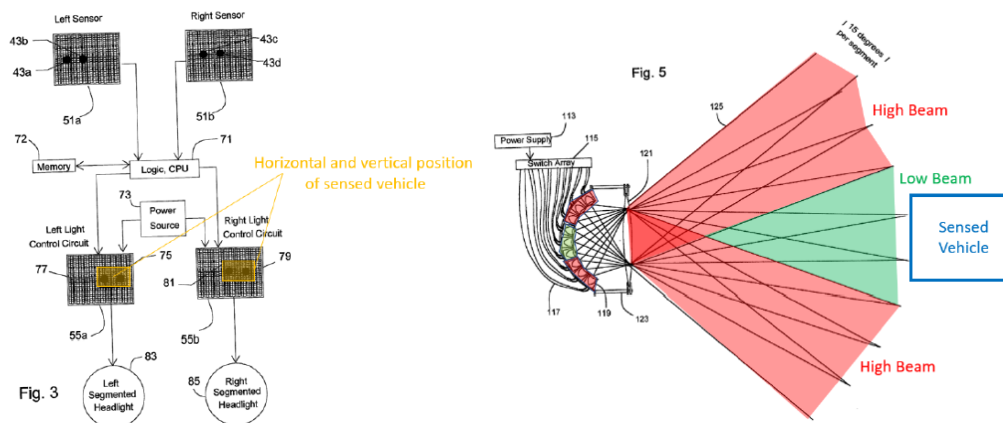
(Ex. 2041, 115:7-16.)

89. Dr. P. explains that Alden includes multiple rows of LEDs in Fig. 5 to provide light above and below sensed vehicle, while dimming the sensed vehicle.

Q. So, if you see in [Alden] Figure 3, which is in paragraph 119 of your declaration, you have high beams all around the vehicle, correct?

A. Yes.

Q. Okay. So, now, if we go back to your [Alden] Figure 5 embodiment, which shows the top view, which LEDs would be used to generate the high beams above the sensed vehicle?



Ex. 1005, Figs. 3 and 5 (Annotated in IPR2023-01034, Ex. 1003, ¶¶119, 126)

A. You see, as Alden discloses, Figures 3 and 4 are used for Figure 5, and, basically, Figure 5 – the paragraph 29, says the following: That these LEDs -- let me -- Paragraph 29 from Alden, Figure 5 illustrates the segmented headlight means – the segmented headlight means a controlling switch array if the first embodiment, and, also, it says, its lighting element being independently controlled by a corresponding switch in an array of switches 115. Each switch is controlled by the CPU and logic previously described. So, as I have said previously, a POSITA will have read this to mean that Figure 5 demonstrates a slice of the LEDs on a curve.

Q. So –

A. Let me -- because this is an important point. The 119 and other lighting elements only care about the focal point, overhead light lens 121, such that the light from its lighting element goes into specified portion or portions. So the combination of the placement of these directed LEDs, along with the focal point of the headlight lens 121 -- this is from paragraph 29 -- will allow, for example, to answer your

particular question, an LED from rows below cover the area above the highlighted-in-yellow box.

Q. So you're saying there would be a row of LEDs below those illustrated in Figure 5 that would provide the light above the vehicle -- the yellow box in the Figure 3 embodiment; is that correct?

A. A row placed vertically. As I have discussed earlier, this is a slice. Because, basically, again, it says, each switch is controlled by the CPU and logic, Figure 4, and Figure 4 has this two-dimensional images provided by the camera sensors and refer to logic that is described in Figure 4.

Q. When you use the term slice, you're referring to, like, a row of LEDs, and there'd be adjacent rows? There'd be multiple rows of LEDs?

A. Yes, a POSITA would have viewed it that way.

(Ex. 2067, 58:7-60:6)

(5) Light output and Shape of the beam

90. During his first deposition, Dr. Papanikolopoulos stated that it would be speculation to describe the beams in the Figure 5 embodiment as overlapping.

Q. All right. So back to the figure 25 [sic 5] embodiment. Do these beams overlap? Do each segment overlap?

MR. HUGHES: Objection. Vague. Compound.

A. From the diagram -- I will only speculate from this diagram.

BY MR. TURNER:

Q. Okay. So, in your opinion, do the beams overlap?

A. Again, I don't want to speculate on this one because I don't have the exact distance between the LEDs, the placement of LEDs, the angle, the curvature associated with this curve that we see here.

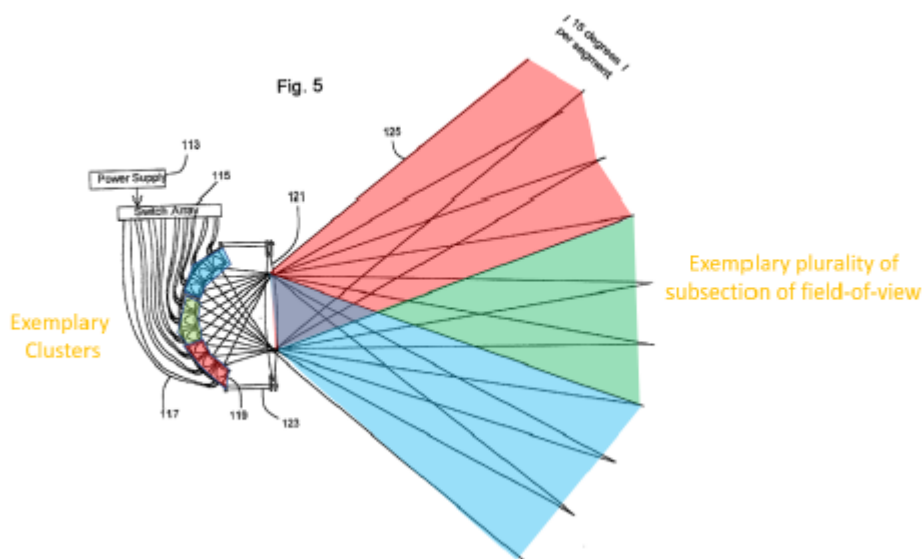
(Ex. 2041, 110:20-111:8.)

Q. So in the scenario when there's not any vehicles present -- so this is not a dim condition -- would the beams -- the output beams in the figure 5 embodiment overlap?

A. I think my answer, again, would be speculation because the issue is there is not so much -- as I mentioned earlier, there are a lot of parameters which -- there are several parameters that come into play: How many LEDs? What is the angle, the curvature of the -- and then the existence or nonexistence of a vehicle or vehicles. Because, in particular, Alden discloses that it can detect multiple vehicles and have multiple dimming zones. It can influence a lot of these optics or the impact of optics as we sense the environment.

(Ex. 2041, 112:19-113:3.)

91. However, in his second deposition, and with reference to paragraph 54 of his declaration, Dr. Papanikolopoulos was able to describe the overlapping beam patterns.



Ex. 1003, ¶54 (citing Ex. 1005, Fig. 5, Annotated)

Q. All right, so which LEDs provide the light pattern that's kind of shown in a purple color in your annotated Figure 5?

A. This is to demonstrate the overlap and is just for illustration purposes.

(Ex. 2066, 62:15-19.)

92. Dr. Papanikolopoulos explains that Alden provides the full beam pattern illustrated in Figure 5 during normal driving conditions.

Q. Okay. But, in normal driving conditions when there's no oncoming traffic and no curves, the Figure 5 embodiment would illuminate the full pattern shown in Figure 5; is that correct?

A. Yes.

(Ex. 2067, 17:21-25.)

c. Control of Intensity and Direction

93. Dr. Papanikolopoulos states that Alden independently controls intensity and direction in the first embodiment (Figure 5). He states that Alden controls intensity by adjusting the electrical power supplied to the LED and controls direction of the LEDs by mounting them on a curved surface and by changing the state of the LED (i.e., turning it on or off).

Q. Okay. So how does Alden teach controlling intensity with reference to the Figure 5 embodiment?

A. So, for example, I'm at paragraph -- give me a minute. Paragraph 74, from my declaration. "To adjust intensity, for example, the power to each individual lighting element is CPU-controlled, such that 'the light sent to the area of 41 [an oncoming vehicle] is dimmed using a headlight with segmented lighting means' (that is, the light elements have independently-controllable light characteristics)."

(Ex. 2066, 69:21-70:5.)

Q. So is it your opinion that when Alden's disclosure that you say is to independently control the direction of the LEDs, that's achieved by turning off the LEDs?

A. I think a POSITA will look at the placement of the LEDs with respect to the lens plus the individually controlled.

* * *

Q. Are you saying that Alden teaches independently controlling the direction of the LEDs by mounting them on a curved surface?

A. Among other things. By telling them basically by switching their state, by having full controllability of their state.

(Ex. 2066, 71:2-7; 72:8-13.)

d. Each LED is controlled by a switch

94. Alden describes each LED of the Figure 5 embodiment as being controlled by a switch of Figure 3.

Q: Okay. So does the figure 3 description affect the total beam spread of the Figure 5 embodiment?

A: The figure 3 can inform. But, again, this is a concept. So if you look at the number of rows on 77, 79, it's not clear how many. Assuming that each element controls one LED, it's not clear and I cannot count here.

* * *

A. In figure 3. It's a reference as an array matrix. In other words, there are rows and columns. So here, basically the disclosure is that each one of these controls one LED. And this is what the POSITA would have understood at that time. So it doesn't give me any information how many rows, how many columns we have. It's a concept diagram. There are no dimensions, no scale.

(Ex. 2041, 108:11-109:5.)

Q. So you're saying the elements 77 in Figure 3, each element in that box would control one LED or one lighting element of Figure 5; is that correct?

A. A POSITA by reading the disclosure could have thought, because basically this is a two-dimensional array, but there are other alternate ways of doing that.

(Ex. 2066, 43:11-16.)

2. Alden's three discrete embodiments are not combinable

95. The significantly different principle of operation and control among the embodiments disclosed by Alden would constrain available options for reconfiguring, combining, or otherwise modifying any particular embodiment(s), even if a POSA had a motivation to do so. Selection of a particular principle of operation, light source(s), lens, etc. may dictate selection of other components, controls, etc. and functionally or practically foreclose selection of otherwise available options disclosed in another embodiment. For example, selection of an LED light source from the first embodiment (Fig. 5) requires multiple LEDs to provide acceptable intensity to maximize the areas receiving high beams while concurrently providing low beams to all areas with other drivers present. The non-collimated, diverging light produced by LEDs requires a converging lens to produce the desired headlight beam. The non-collimated light is not suitable for use with electro-optic elements of the second or third embodiments. Collimating the light from LEDs, or controlling intensity using electro-optic elements, would result in additional losses and require additional LEDs to maximize the areas of

high beam light.

96. Similarly, other substitutions or reconfigurations—e.g. of a single light source, or to selection of electro-optic elements to control intensity, or selection of various other aspects-- would impact the functionality of the system and could necessitate a myriad of other modifications to produce an operative system.

97. I understand that Dr. Papanikolopoulos relies on Alden's disclosure in ¶[0061] for supporting combining different embodiments of Alden:

While the above description describes many specifications, these should not be construed as limitations on the scope of the invention, but rather as an exemplification of a preferred embodiment thereof. Many other variations are possible. For example, light sectors may overlap such that one light distribution sector is covered by more than one illumination emitting, filtering, and/or diverting sectors. One or more methods employed herein may be used in combination to vary illumination in a segmented system. Many light detector (wherein electromagnetic radiation is converted to an electric signal) techniques can be used herein as sensors, for example, photodiode, CCD etc. The segmented distribution light can be used for many applications other than motor vehicles. For example it can be used to shine light only where needed to conserve electricity when used in conjunction with a motion sensor. It will be understood that the present invention can also be used to operate a segmented light distribution system to provide illumination to independently controlled segments each

operable within a range of intensities between the high beam and the low beam state.

(Ex. 1005, ¶[0061].)

98. Alden's broad statements in paragraph 61 do not explain which if any embodiments could be combined and if so, how they would be combined. Further, because the first embodiment uses a significantly different principle of operation and control relative to the second and third embodiments, Alden does not disclose or suggest combining or otherwise modifying these embodiments. Similarly, even if a POSA could rearrange components disclosed by Alden, there is no reason that a POSA would be motivated to do so due to the different principles of operation and corresponding different optical components and control strategies that are not interchangeable or combinable. For example, use of multiple light sources vs. single light source, use of forward facing light sources vs. rearward facing light source, use of extended, curved light source vs. point light source, use of collimated light and collimating reflector vs. non-collimated light, use of converging double convex lens vs. diverging double concave lens, controlling power supplied to light source(s) vs. controlling power supplied to electro-optic elements, controlling intensity by controlling power to the light source(s) vs. controlling intensity by filtering or redirecting light from the light source(s), etc. would limit the modifications or substitutions of components, particularly those of

the first embodiment with either the second or third embodiments disclosed by Alden.

a. A POSA would not have been motivated to combine Alden's LED Array of Embodiment 1 with a refractive opto-electric element of Embodiment 3

99. Dr. Papanikolopoulos proposes adding one refractive element to the Figure 5 embodiment, while keeping the lens 121:

Q. Okay, so how would a POSITA have added this refractor element to the Figure 5 embodiment?

A. So, for example, let me go to figure -- so let's suppose, for example, if you go to Figure 5, let's suppose that we are going on a curve and we want to have more light directed to the right, to the bottom of the figure, because basically we have an upcoming curve, so in addition to the reflectors or after detecting the reflectors on the curve, we want to have more control of the light that goes on the side of the road. So the element -- the first element from the top, the first LED element, we can put a refractor, which is basically it's quite small, we can put it as close to the LED as possible, among other options.

Q. You're saying taking the refractors that are in the figure, let's see, was that Figure 10; is that correct? And you're adding that to the Figure 5 embodiment?

A. No, I'm taking the single liquid crystal, so the element I believe -- just let me make sure that I have it right -- if you look at the element

of 141, paragraph 33, Figure 8, it says in the third embodiment the electro-optic material 141 is a liquid crystal. So what I'm saying, taking this element 141 and place it on Figure 5 as close to the LED as possible.

(Ex. 2066, 79:3-80:3.)

Q. Okay, so you're inserting this -- you're adding this to the Figure 5 embodiment between the LEDs and the lens 121 or are you removing lens 121?

A. A POSITA will have the option depending on the particular task but in this case in this scenario that I mention in the context I mention before, **we can keep the lens.**

(Ex. 2066, 80:11-17.)

100. Dr. Papanikolopoulos states that a POSA could add an opto-electronic refractive element as shown in the third embodiment of Figures 8-9 to the first embodiment LEDs of Fig. 5 or move an LED outside of the headlamp and create a second headlamp assembly with one LED and one refractive element.

Q. Okay. So how would a person of ordinary skill in the art add a variable refractive element to the figure 5 embodiment?

* * *

Q. Okay. So if that explains it, would you mount this to the figure 5 embodiment between LEDs and the lens 121?

A. I said there are other few options among -- and I will start with partial substitution. Because I have to consider this as part of the particular content in patent 029.

Q. Okay. So what elements are you substituting?

A. One option, as I mentioned earlier, is just substituting or adding on the side of the LEDs.

Q. Are you adding the full array of refractive elements or a single one?

A. It can be a single one.

Q. Okay. So if you're adding those to the side of the LEDs, is the LEDs in -- illustrated in figure 5; is that correct?

MR. HUGHES: Objection, mischaracterizes.

THE WITNESS: I'm saying in the case of basically where we want to bend the light in a certain direction, and if, basically we have lack of additional sensory signals, one of the things you can do is actually adding them on the side so, basically, you can have more control along the curve, as a POSITA.

BY MR. TURNER:

Q. So when you're saying adding these to the side of the LED, by adding a refractive element to the side of the LED, that's within the beam path between the LED and the lens 121?

MR. HUGHES: Objection.

BY MR. TURNER:

Q. – is that correct?

MR. HUGHES: Mischaracterizes.

THE WITNESS: I'm saying on the side so the bending will happen -- it will not interfere.

BY MR. TURNER:

Q. So can you be more specific what you mean by at the side with reference to figure 5? Where exactly would this refractive element be located?

A. So it can be a structure as denoted in Figure 10, that goes, for example, where 119 is next to it.

Q. By next to if, do you mean within the light path between the LED and the lens 121?

A. No. I mean, if we want to have something as a first option next to it.

Q. What do you mean by next to it?

A. Do you see where we have 119 and a pointer?

Q. Yes.

A. So there is some space next to this LED. Or the other one is to take this LED 119 out, leave the rest, take the one out which is on the other symmetrical position of this top view, and have this refractive element there.

Q. So you're saying -- you're describing two options. One would have the refractive element within the housing between a light element 119 and the lens, 121; is that correct?

That's one option?

A. And there are other options.

Q. So and the other option you mentioned was moving the element 119 outside of this housing?

A. Yeah.

Q. And then just --

A. Just removing this. Just removing this element completely.

Q. Just one single light element out of the series or the array?

A. You may have to remove more, depending on how these are located along the focal point of the head lamps and a number of -- the total number of LEDs we have.

Q. All right. So this LED would it be used only for curve illumination or would it also be used for forward illumination?

A. In the context of the patent 029, I will see the need or the motivation to do proper care or the POSITA would have examined these as an option.

(Ex. 2067, 72:2-75:8.)

101. As described above in ¶¶95-98, Alden's LED embodiment is not combinable with the controllable refractive element embodiment, and even if a POSA could rearrange components disclosed by Alden as suggested by Dr.

Papanikolopoulos, there is no reason that a POSA would be motivated to do so due to the different principles of operation and corresponding different optical components and control strategies that are not interchangeable or combinable.

102. Intentionally left blank.

B. Harbers

103. Harbers discloses a headlamp system having fixed, planar LED arrays with groups of LEDs associated with different illumination functions. As depicted in Figure 1B of Harbers, a “headlamp (2; 3) of a vehicle (1) has a light source (4; 5) comprising a plurality of opto-electronic elements (11; 12; 13; 14), preferably light-emitting diodes (LEDs). . . . [T]he light beam generated by the light source (4; 5) ... comprises at least two light beam segments (6, 6'; 7,7')” which define the spatial distribution of the light beam. (Ex. 1006, Abstract.)

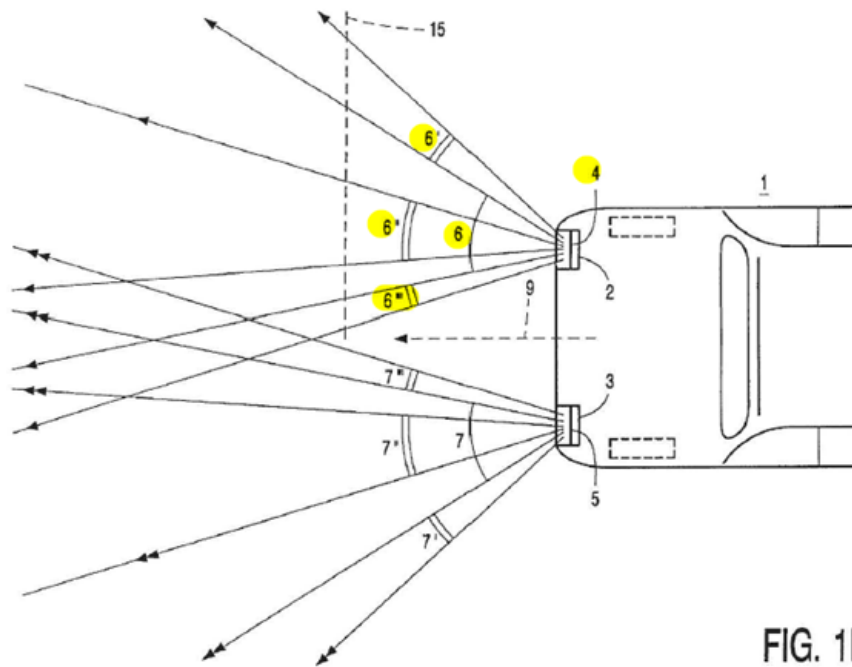


FIG. 1B

(Ex. 1011, FIG 1B, Annotated)

104. As depicted in the asymmetric light distribution patterns of FIGS 3A and 3B, Harbers discloses a headlamp that provides light along multiple optical axes. (Ex. 1006, FIGS 3A and 3B.) Spatial distribution of the light beam is achieved by selectively switching on and off individual LEDs and the corresponding light beam segments. (*Id.*, 7:15-19, 8:21-25.)

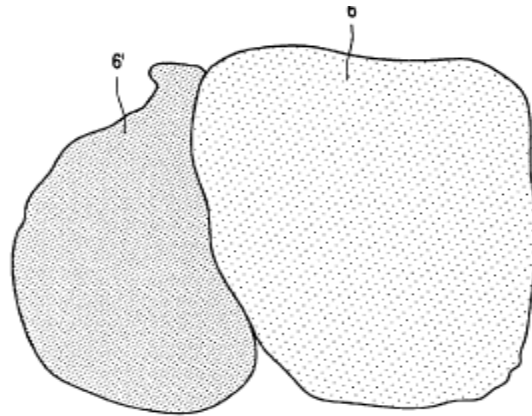


FIG. 3A

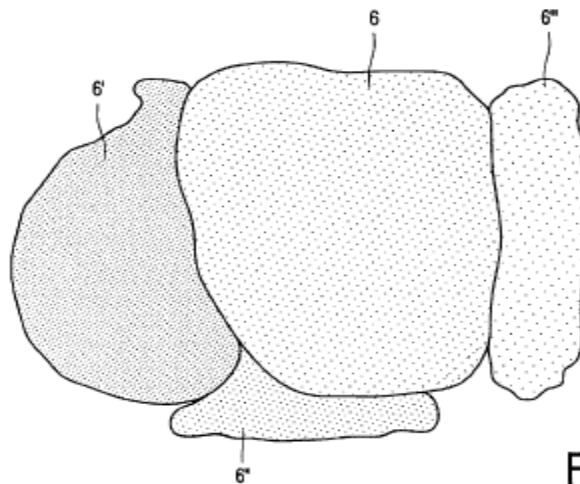


FIG. 3B

(Ex. 1006, FIGS 3A, 3B)

105. Harbers identifies specific parameters that can be used to define the desired spatial distribution of the light beam. Per Harbers, “the spatial distribution of the light beam can be influenced by the velocity of the vehicle.... It may also be desirable for the width of the light beam to decrease and/or the intensity distribution between on-axis viewing and off-axis viewing to change.” (*Id.*, 3:28-30, 3:33-4:1.)

106. In another embodiment, Harbers discloses that:

the spatial distribution of the light beam can be influenced by the rotational position of the steering wheel of the vehicle. This enables the spatial distribution of the light beam of the vehicle headlamps to be adapted to the position of the steering wheel of the vehicle.... By switching on or off one or more opto-electronic elements at specific-limiting values of the rotational position of the steering wheel of the vehicle, a continuously adjustable spatial distribution of the light emitted by the vehicle is obtained.

(*Id.*, 4:6-14.)

107. In yet another embodiment, “the spatial distribution of the light beam can be influenced by the weather conditions.” (*Id.*, 4:16-17.) In a final embodiment, “the spatial distribution, for example[,], the range and/or the width of the light beam, . . . [may] be adjusted by the driver” of the vehicle. (*Id.*, 4:24-25.) Apart from the above-identified inputs that could be used to define the spatial distribution of the light beam, Harbers provides no control teachings related to sensors or map data and thus no ability to control the LEDs to illuminate a desired region.

108. Intentionally left blank.

109. Intentionally left blank.

C. Bergkvist

110. Bergkvist uses a light source, such as a gas discharge lamp, that

produces both visible and UV light, combined with a lens filter that blocks high-beam visible light that would dazzle oncoming vehicles while passing UV high-beam light to illuminate signs and objects having fluorescing day-glow paint or ink. The headlight may include an additional conventional halogen lamp that produces a full beam lobe to provide high-beam visible light, which must be dimmed when two vehicles meet. (Ex. 1007, 2:7-24; 4:35-39.)

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112. Intentionally left blank.

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D. Beam

114. Beam discloses an Adaptive Anti-Blinding Headlight (“AABH”). (Ex. 1008.) Beam recognized that existing headlight systems operated “either as a ‘high beam’ or as a ‘low beam’” often under manual control, and various unsatisfactory attempts to solve this problem included:

systems which attempt to control the intensity profile of the beam by using a reflector or lens shaped to control the output beam in some predetermined way; systems to move the headlamps in response to changes that occur to the automobile on which they are mounted; . . . movement of headlight beams in response to changes in the vehicle's steering mechanism, etc.

(*Id.*, 1:21-22, 1:63-2:5.)

115. Beam solves the identified problems by providing a non-moveable AABH system having a multiplicity of microbeams that “will operate at maximum intensity at all times” allowing “the driver to have the equivalent of high beam headlights or brighter on at all times, greatly enhancing the ability to see at night.” (*Id.*, 6:11-12, 6:54-56, emphasis added.) Beam further discloses that:

From the viewpoint of the driver of an automobile equipped with AABH, it will be like having bright high beams on at all times but without concern that the other motorists within the extent of his headlight beam will be dazzled.

* * *

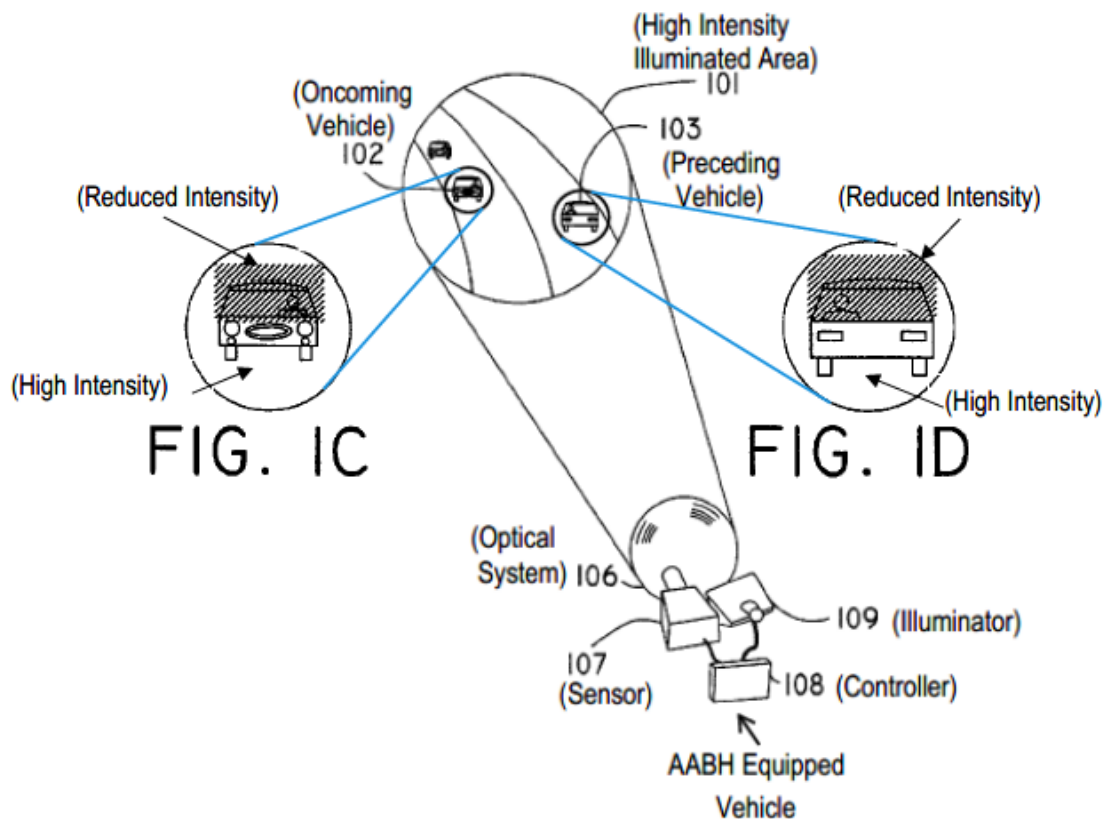
Accordingly, several objects and advantages of this invention are to provide greatly improved safety and comfort to the motoring public, in particular, and to others who may be affected by them by providing the driver of an automobile equipped with the instant invention with a far brighter headlight beam while simultaneously protecting the drivers of all vehicles ahead from being dazzled by the light.

(*Id.*, 6:40-44, 3:8-15.)

116. A POSA would have understood that Beam teaches providing a high beam operating at maximum intensity at all times in the illuminated region, other than any areas around detected light sources from other vehicles.

117. Beam provides significantly **reduced** illumination only in those portions of the headlight beam that would otherwise dazzle or annoy other drivers.

This is accomplished by “darken[ing] those microbeams that would otherwise illuminate areas near to the source of the impinging beam, thus eliminating the blinding of a driver in an oncoming vehicle, while continuing to provide intense forward illumination.” (*Id.*, 1:15-19, Claims 4, 5, emphasis added.) While Beam discloses blanking or darkening microbeams that would otherwise dazzle other drivers, it does not disclose or teach changing direction of any microbeams exiting the lamp.

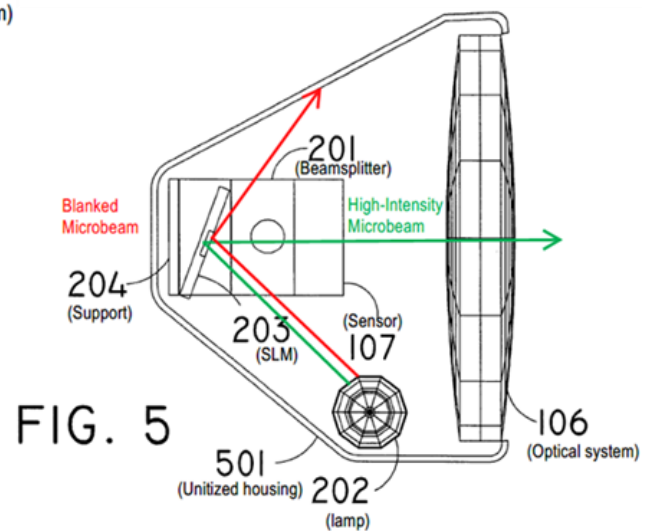
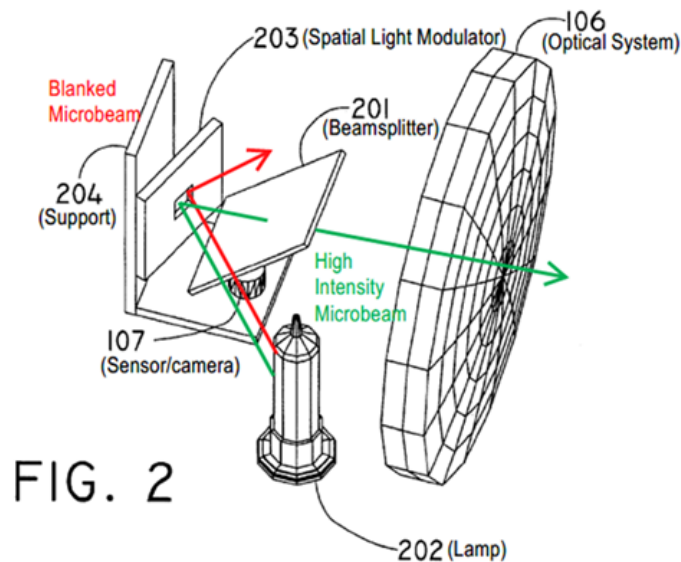


(Ex. 1008, FIG. 1C, 1D, Annotated)

118. In the AABH system, illuminator 109 projects individually controlled narrow-angle microbeams to provide high-intensity illumination of illuminated

area 101. Headlights of an oncoming vehicle 102 and/or taillights of a preceding vehicle 103 are transmitted through optical system 106 and detected by a sensor (camera) 107. Data from sensor 107 is used by controller 108 to map the “angular position of the vehicles ahead” to a corresponding position/size of microbeams that must be significantly reduced in intensity corresponding to the shaded areas shown for oncoming vehicle 102 in Fig. 1C, and preceding vehicle 103 in Fig. 1D. (*Id.*, 4:9-24, 29-30, 46-49, 53-59, 62-64.)

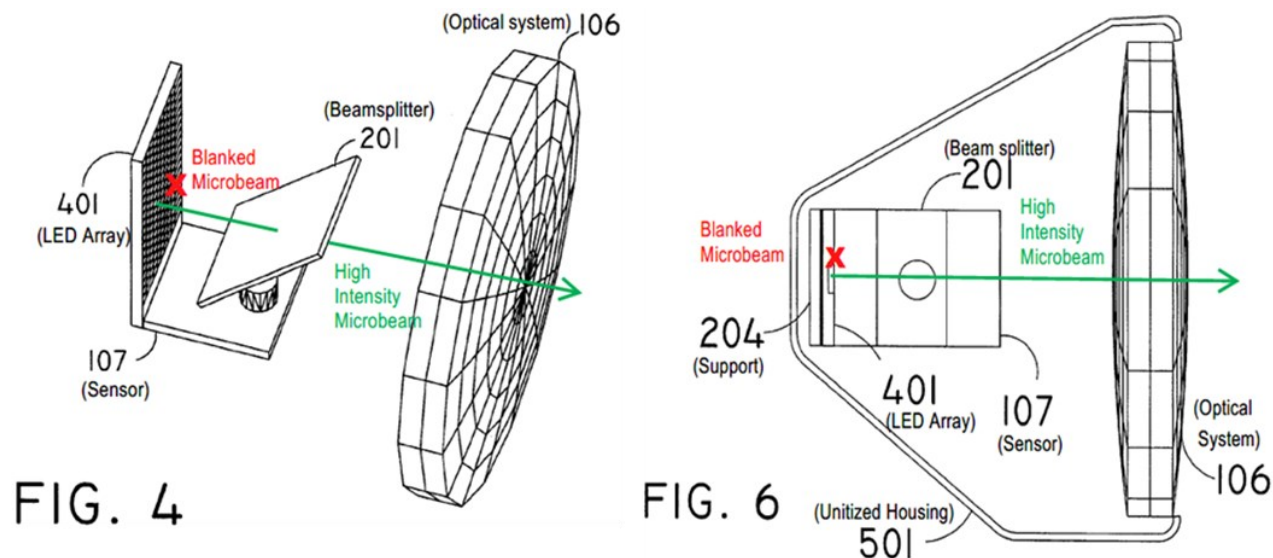
119. Beam describes two distinct embodiments using alternative components that significantly reduce illumination intensity of individual microbeams in response to detecting incoming headlights/taillights or other light sources. However, neither embodiment discloses increasing intensity beyond the maximum intensity for any microbeams, or changing direction of any of the microbeams exiting the lamp.



(Ex. 1007, FIGs. 2, 5, Annotated)

120. In the first embodiment illustrated in Fig. 2 (perspective view) and Fig. 5 (top view), light from lamp 202 falls on spatial light modulator (SLM) 203, which is controlled so that the associated individual microbeams are either 1) reflected by SLM 203 at full intensity through beam splitter 201 and out through headlamp optical system 106, or 2) “blanked (attenuated by being either absorbed or deflected [by SLM 203] to an absorbing surface” so that they do not exit the headlamp optical system 106. (Ex. 1007, 4:36-41, emphasis added.) While SLM 203 blanks one or more microbeams by deflecting the blanked microbeams to an internal absorbing surface of the headlamp 503, it does not change direction or angular position of the headlamp beam exiting optical system 106 because the blanked microbeams are “diverted or attenuated at the source” and never exit the headlamp optical system 106. (*Id.* at 5:66.) The Beam SLM 203 appears to work in

a similar fashion as a digital light processing (DLP) chip that was in existence on or before the time of filing of the Beam Patent and is used in DLP projectors.



(Ex. 1007, FIGs. 4, 6, Annotated)

121. The second embodiment is illustrated and described with respect to Fig. 4 (perspective view) and Fig. 6 (top view). The second embodiment replaces both SLM 203 and lamp 202 used to generate and modulate (reduce) intensity of the microbeams of the first embodiment, with an array of light sources 401, such as an LED array, that generates the narrow-angle microbeams. Microbeam blanking is accomplished by dimming one or more of the LEDs making the modulator of the first embodiment superfluous, and it is thus omitted from the second embodiment. (*Id.* 5:3-9, 13-15.)

122. In operation, light from oncoming/preceding vehicles or other sources enters through optical system 106 and is reflected by beamsplitter 201 to sensor

107. The sensor signals corresponding to the angular position (azimuth/elevation) or spatial location of the detected light are mapped by controller 108 to associated microbeams to determine the size (number) and location of the LEDs within LED array 401 to be blanked or dimmed to prevent blinding/dazzling other drivers. The output of the active LEDs creates the high-intensity microbeams projected out through optical system 106. (*Id.*, 5:9-16.)

123. Intentionally left blank.

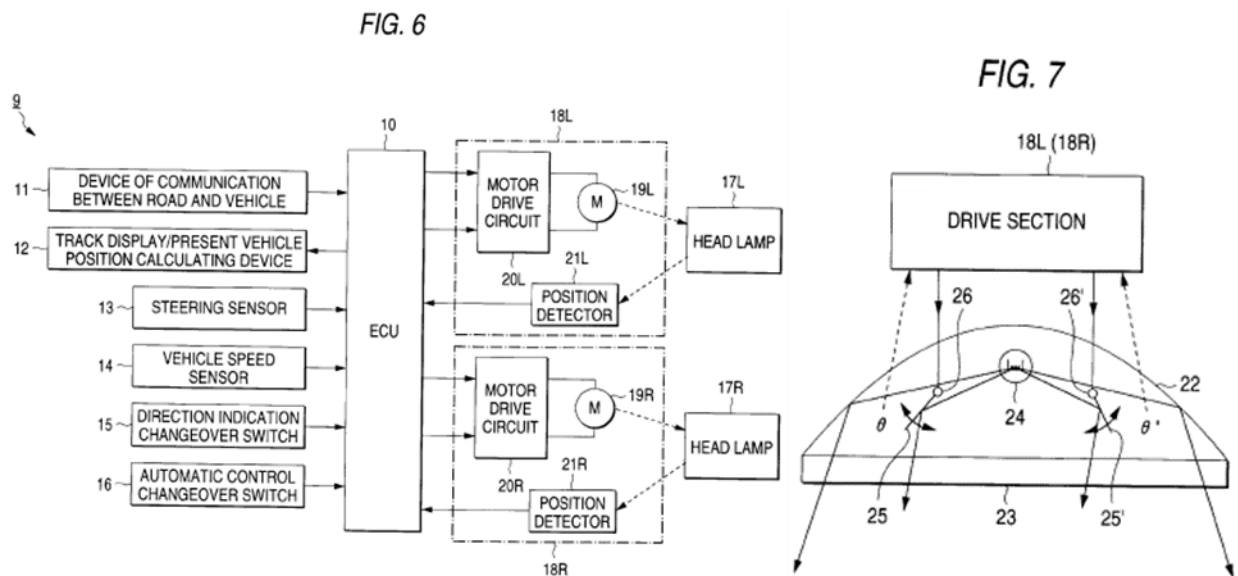
124. Intentionally left blank.

E. Kobayashi

125. Kobayashi discloses a “Lighting Device for a Vehicle.” (Ex. 1009.) Kobayashi is directed to a headlight control system that changes direction or range of a headlight beam using map information unless a predicted vehicle travel direction as indicated by a turn indicator, steering angle, and vehicle speed/acceleration differs from the map data, i.e., “[w]hen the vehicle advancing direction at which the driver aims does not coincide with the profile of the road.” (*Id.*, 2:35-37.) More specifically, Kobayashi discloses a headlamp system with moveable components to control irradiation (illumination) direction and range in accordance with a road profile when the vehicle travels along a scheduled course, or in accordance with a steering angle and vehicle speed when the predicted advancing direction of the vehicle deviates from the scheduled course (*Id.*, 6:4-10;

17:59-67.) A “mechanical” and “moveable” system as used in this context refers to a system with moving parts and/or mechanisms to position the light beam.

126. Kobayashi changes irradiation direction using a motor to either rotate the entire lighting device about its axis, or to change relative position among internal lighting device components, such as a reflecting mirror, lens, light source, or shielding member. (*Id.*, 6:11-39.) Irradiation range is controlled by either combining different lighting devices with each other (such as a fog lamp, head lamp, and cornering lamp), or by controlling a motor to change position of the internal components (such as reflecting mirrors lenses, or shades) relative to one another. (*Id.*, 6:40-7:14.) Irradiation range may be changed responsive to a branch (intersection) ahead on a road by moving the internal lighting device components to change a horizontal irradiating angle α . (*Id.*, 8:1-32.)

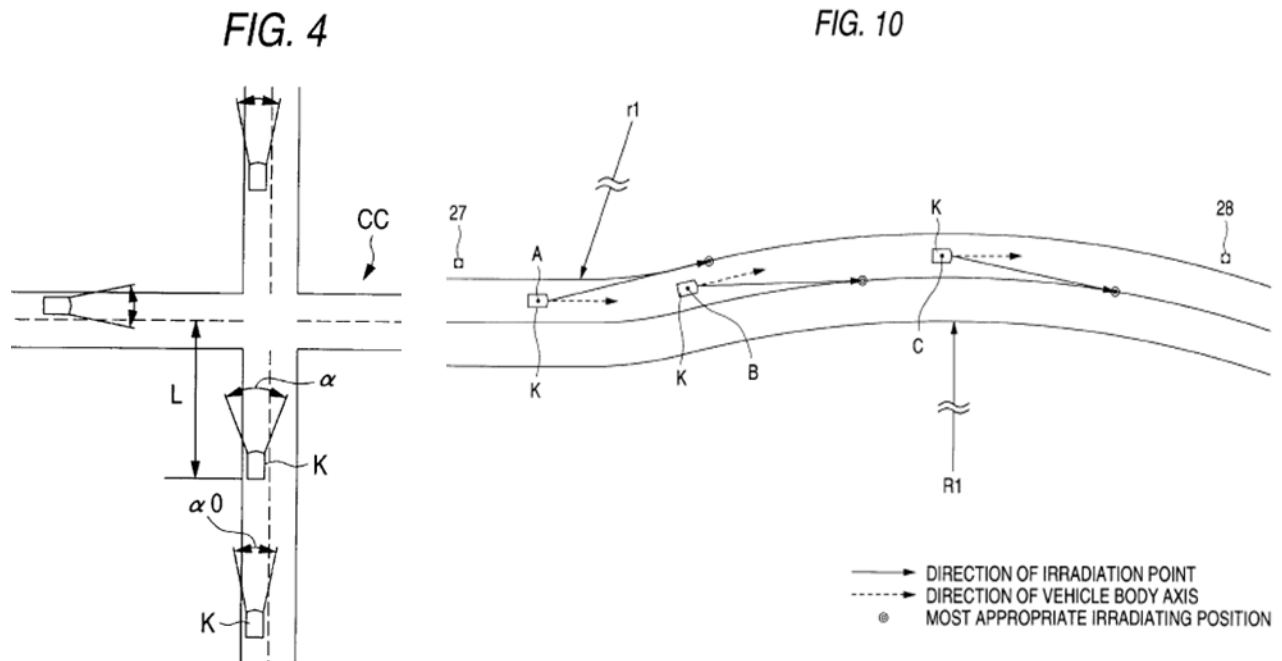


(Ex. 1006, FIGs. 6, 7)

127. Kobayashi's ECU 10 receives signals from: communication device 11 (conducting communication between a road and vehicle), track display/present vehicle position calculating device 12, steering sensor 13, vehicle speed sensor 14, direction indicating switch 15 and automatic control change-over switch 16. ECU 10 generates signals for drive sections 18L, 18R of head lamps 17L, 17R arranged on the left and right front portion of a vehicle. (*Id.*, 10:1-17.) Drive sections 18L, 18R include associated motor drive circuits 20L, 20R to drive associated motors 19L, 19R with position detectors 21L, 21R to detect the posture of the head lamps 17L, 17R or their composing members (internal components). (*Id.*, 10:66-11:4.)

128. Figure 7 illustrates a headlamp with moveable composing members to control the direction and range of irradiation. Light source 24 and movable reflecting mirrors 25, 25' are positioned between stationary reflecting mirror 22 and front lens 23. Movable reflecting mirrors 25, 25' are rotated about respective rotating axes 26, 26' by a link mechanism to a rotation angle (θ , θ') to provide partial direction control of irradiating light. (*Id.*, 11:5-14.)

129. Figures 4 and 10 illustrate operation of the moveable composing members of the headlamps to control irradiation range and direction while approaching an intersection and running on a curved road, respectively. (*Id.*, 2:48-49, 65-67.)



(Ex. 1006, FIGs. 4, 10)

130. As shown in Figure 4, Kobayashi's headlamp motors are operated to increase horizontal irradiating angle α_0 to $\alpha > \alpha_0$ based on a distance L from intersection CC and vehicle speed. (*Id.*, 8:14-25.) In Figure 10, the headlamp motors are operated according to road profile information and vehicle speed to change the irradiating direction toward a determined irradiating position for the driver's line of sight at each position of the vehicle. When the vehicle turns to the left at point A, the left shoulder is irradiated. When the vehicle turns to right, the right shoulder is irradiated, etc. If the driver operates the steering wheel by an angle larger than necessary for the curve, irradiation control is conducted in accordance with the vehicle advancing direction predicted by the steering angle. (*Id.*, 14:53-15:39.)

131. Intentionally left blank.

132. Intentionally left blank.

133. Intentionally left blank.

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IX. Alden's disclosure requires speculative interpretation or modification to operate as described in the Petition

A. Alden does not anticipate the challenged claims

135. The Petition describes how the Figure 5 embodiment operates—including color coding beam segments to explain their functionality and specifying the location of a vehicle in the beam pattern. However, Dr. Papanikolopoulos stated in his deposition that he would need to speculate on how Alden would operate and/or need to modify Alden to operate as shown.

136. Petitioner's contentions as well as statements in the Institution Decision regarding the general and broad functionality of Alden's first embodiment illustrated in Figure 5, assume without support from Alden that the illustrated and described row of LEDs is only one of many such rows. (Petition, 13-15; DI, 9-10.)

137. Regarding the Figure 5 LED first embodiment, Alden describes a single, curved row of LEDs positioned along the focal point of a lens. (Ex. 1005, ¶[0029], Fig. 5.) Alden never mentions any additional rows/columns of LEDs other

than the single curved row of LEDs shown in Figure 5. When asked about this, Dr. Papanikolopoulos explained a variety of configurations and placements of LEDs, none of which are expressly illustrated or described in Alden. (Ex. 2066, 35:10-13, 47:7-11.) That is in addition to his prior testimony, where he could only posit that there were “many variations” of possible placement of rows. (Ex. 2041, 119:9-22.)

138. In his first deposition for related proceedings, IPR2023-01039 and IPR2023-01040, Dr. Papanikolopoulos stated that: 1) Alden’s Figure 5 embodiment is a “high-end schematic”; 2) Alden lacks specific details on how the sensing and control elements of Figure 3 inform the operation of the Figure 5 embodiment; 3) Figure 5 requires “much speculation because . . .there are a lot of [missing] parameters which come into play: How many LEDs? What is the angle, the curvature”; and 4) these missing parameters constrain the expert’s ability to determine the Figure 5 beam shape, number of LED rows, placement of LED rows, etc.. (Ex. 2041, 56:25-57:11; 112:19-113:3; 108:11-109:5.) By way of example, Dr. Papanikolopoulos indicated that it is “*not clear*” and could not explain how the switch array shown in Figure 3 controls the LED array shown in Figure 5 to create the beam spread illustrated therein:

Q. Okay. So does the figure 3 description affect the total beam spread of the figure 5 embodiment?

A. The figure 3 can inform. But, again, this is a **concept**. So if you look at the number of rows on 77 and 79, it's not clear how many. Assuming that each element controls one LED, **it's not clear and I cannot count here.**

* * *

A. In figure 3. It's a reference as an array matrix. In other words, there are rows and columns. So here basically the disclosure is that each one of these controls one LED. And this is what the POSITA would understand at that time. So **it doesn't give me any information how many rows, how many columns we have. It's a concept diagram. There are no dimensions, no scale.**

(Ex. 2041, 108:11-18; 108:23-109:1-5.)

139. Complicating the issue, in his first and second depositions, Dr. Papanikolopoulos identified, for the first time, at least three modifications that would be required of the Figure 5 express teachings. A first modification involves the number of LEDs to “reach the lumen output required”:

Q: [Y]ou're citing to the '503 patent, does this help explain the teachings in Alden?

A: No. So what I'm trying to say that **in order to reach the lumen output required, basically you need to have more than what basically we have here in this demonstrative or illustrative figure.** So going back to your question, **you may have in the next row below an LED or you may have an expanded row with more LEDs....**

Q: Are you saying you might need more LEDs and more refractive elements just to provide sufficient lighting for this functionality that you're trying to achieve?

A: No, what I'm trying to say is actually this Figure 5 for a POSITA will have meant that **this is only one slice of the tons of LEDs that you need, number of LEDs ... that you need in order to have this – basically this segmented headlight system.**

(Ex. 2066, 99:11-100:5.)

140. Second, Dr. Papanikolopoulos modified the arrangement of LEDs, by stating that the Figure 5 embodiment “will be multiple – so think of stacks of this section that are going to form the – basically, the array of LED elements that corresponds to this control switch which is shown in Figure 3[.]” (Ex. 2041, 115:25-116:5.)

141. Dr. Papanikolopoulos, testified that, “slice to slice,” the LED placement would be adjusted “closer to or further from the lens” to “capitalize on the focal point”:

Q: [I]f it's a very clear teaching, can you explain what the shape of this lighting structure is that's described with reference to Figure 5, as a shape?

A: ... what is very clear here is that **this is not – the LEDs are not on a flat surface....** as basically we move from slice to slice, the LEDs are placed closer to the lens or further away in order to capitalize on the focal point....

Q: [A]re you saying the slices of LEDs or rows of LEDs have different numbers of LEDs, different shapes?

A: ... the disclosure informs the POSITA, place the LEDs in a way that you maximize the collaboration, the cooperation between the LED elements and the lens, **which means as you get different slices, you may want to place them closer to the lens or further away from the lens.**

(Ex. 2066, 47:1-19.)

142. The Petition does not identify any of these modifications and further does not explain why a POSA would “at once envisage” these modifications to achieve the claimed segmented headlight system.

B. Dr. Papanikolopoulos testified that Alden’s Figure 5 embodiment is inoperative without modification

143. The Petition relies on the Figure 5 embodiment (operating with Figures 3 and 4) that, as explained by Dr. Papanikolopoulos, is inoperative absent modification: “in order to reach **the lumen output required**, basically you need to have more than what basically we have here in this demonstrative or illustrative figure.” (Ex. 2066, 99:11-16¹⁴.) Thus, per Dr. Papanikolopoulos, to create an operative “segmented headlight system” and “to reach the lumen output required,” the Figure 5 embodiment **requires** modification to have more LEDs “than what

¹⁴ Emphasis added unless otherwise indicated

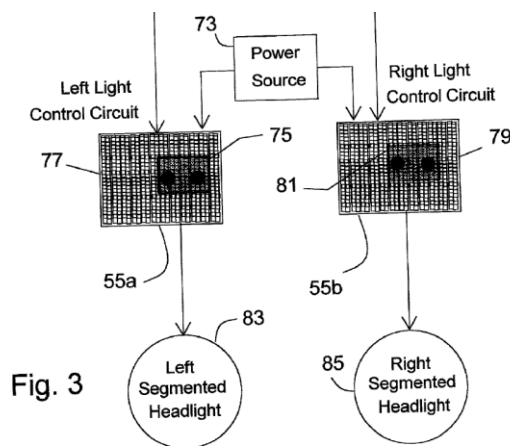
basically we have here in this demonstrative or illustrative figure.” (*Id.*)

144. A similar functional defect arises with how each of the nine LEDs shown in the Figure 5 embodiment are powered by the switch array disclosed in Figure 3. The Petition states that “in Figure 5, [] the lighting elements are ‘individually controlled’ by a ‘switch array,’ with each switch being ‘controlled by the CPU and logic previously described. For example, the power to 119 is controlled by the CPU which dictates its respective switch characteristics at 115” (Petition, 20.) Alden’s requirement that each LED be controlled by a “corresponding switch” — which Dr. Papanikolopoulos repeatedly confirmed in his deposition — requires speculative interpretation or modification beyond Alden’s description to ensure that each LED is correctly powered per Alden’s teachings. (Ex. 1005, ¶[0029].) Since there are 576 switches in the Figure 3 switch array and 9 LEDs in the Figure 5 LED embodiment as shown, absent some unspecified modification, it is unclear what switch or switches would be “a corresponding switch” to each LED as required by Alden. (Ex. 1005, ¶[0029], Figs. 3, 5.) If each switch independently provided power to an LED, and the array was evenly mapped, for example, then each LED would receive power from 64 switches and have control attempted, via power provision, by 64 different switches..

145. “[T]he 55a [switch array] **controls the power flow from 73 [power**

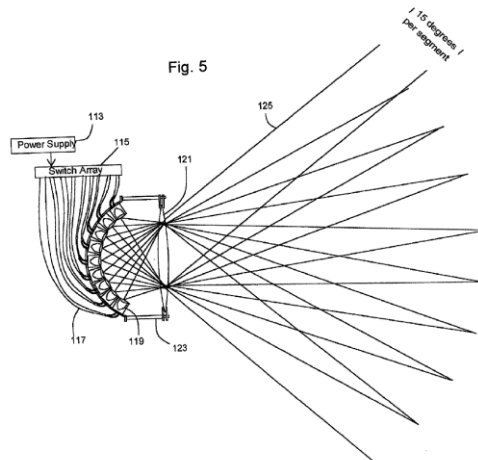
source] to a left segmented headlight...”. (Ex. 1005, ¶[0027].) The overlap of the bounding box (dimmed area) with a switch, causes that switch to control power differently. Assuming even a simple mapping of multiple switches to a single LED, it is unclear how many or which ones of the switches need to be overlapped by the bounding box to reduce power to operate the corresponding LED in the low beam state.

146. If the array shown in Fig. 3 were used to control the switches shown in Fig. 5, with “columns” of the array were mapped to corresponding LEDs of Fig. 5, Alden does not describe how the bounding box pattern shown in Fig. 3 would turn a single LED to the “low beam” state because each column has numerous switches above and below the bounding box that would still instruct “high beam” power to the same LED.



(Ex. 1005, Figure 3)

(Figure 3 depicting a switch array with enabled switches in each column.)



(Ex. 1005, Figure 5)

(Figure 5 depicting a single curved row of LEDs that would require columnar blanking.)

147. Alden neither explicitly nor implicitly describes operation of the Figure 3 switch array **as shown** and the Figure 5 LEDs as relied on in the Petition and it is unclear whether such a system would result in in the dimming of light from any LEDs while maximizing the areas of high beam illumination as described.

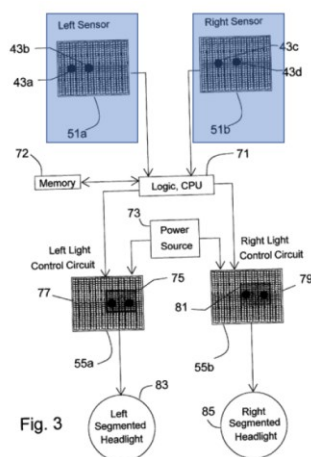
148. Intentionally left blank.

X. Grounds for Challenge

A. Ground I – Alden fails to anticipate at least certain limitations of the claims 1-4, 7, 10-17, 19-23, 25-27 and 30-36

1. Independent Claim 1

a. Element 1[C]: *the subsections determined in response to sensor data*



(Petition, 17)

149. Petitioner explains – “a left shaded circuit area 75 indicates the areas of a segmented headlight control switch array switches which will cause portions of the left headlight to be dim while a non-shaded left circuit area 77 represents the portions of the segmented headlight which will be on high beam.” (Petition, 18.) Thus, in this example, the shaded areas represent a region bounding and extending beyond source locations (“bounding box”), to encompass one or more switches of the respective control circuits.

150. Petitioner considers the shaded bounding boxes 75, 77, to be the determined subsections as required by the claim element, correlating those boxes to the “headlight distribution sectors.” (*Id.*, 17.)

151. Intentionally left blank.

b. Element 1[D]: *electronic control circuitry*

configured to independently operate the light clusters

152. Petitioner relies on Alden's control circuits 55a, 55b as meeting this claim limitation. (Petition, 18-19.) According to Petitioner, "where data from sensors 51a, 51b indicates the presence of another vehicle 41, the control circuitry 'controls the power flow' so the headlight 'distributes high beams throughout its distribution areas except in a box in the direction of the 41.'" (*Id.*, 19-20.) There is no explanation as to any modification of the bounding box, the sensor array or the control circuitry.

153. Petitioner does not explain, and Alden does not describe how the multiple switches of Figure 3 would be mapped to each LED of Figure 5.

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155. Intentionally left blank.

156. Intentionally left blank.

c. Element 1[E]: *one or more sensors configured to obtain and provide the sensor data predefined as pertinent to illumination requirements for the field-of-view*

157. Petitioner notes, "Alden discloses ... [that] the sensor data comprises detection of 'illuminated spot[s]' 'fall[ing] upon a photon detector array which otherwise doesn't receive significant light.'" (Petition, 20.) Petitioner, then describes the logic of Alden's system as interpreting this data as headlights of an

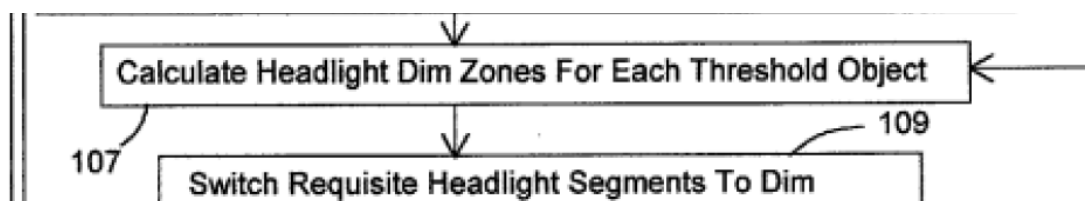
oncoming vehicle, and that Alden's CPU selects portions of the segmented headlight system to dim based on this data. (*Id.*, 20-21.) Thus, Petitioner concludes that Alden: 1) detects light ("illuminated spots"); and 2) determines that detected light is the headlights of an oncoming vehicle.

158. Intentionally left blank.

159. Intentionally left blank.

- d. Element 1[F]: Alden does not teach or disclose *a processor . . . configured to . . . determine an illumination for at least two of the sub-sections, . . . that reduces illumination to reduce glare in at least a first of the two subsections***

160. According to Petitioner, the CPU in Alden can "determine[e] the 'distance and intensity of each object sensed in a calculat[e] process 101'[]" and calculating distances to objects using 'a triangulation process 105.'" (Petition, 23-24.) Petitioner further states "[t]he distance data is then used to 'determine the intensity of light that will be produced by the 61 [headlight] in the corresponding sectors,' as shown in step 107[.]" (Petition, 24.) This is incorrect as step 107 shows the following:



Ex. 1005, Fig. 4

161. Step 107 is described in Alden as representing "[t]he location of

objects [being] used to calculate which zones of each headlight need to be dimmed in a calculate headlight dim zones process 107,” with no mention of the use of distance data. (Ex. 1005, ¶[0028].) Separately, Alden discloses that “distance information is used to determine the intensity of light that will be produced by the [headlight] 61 in the corresponding headlight sectors,” -- but neither Alden, nor Petitioner, explain *how* distance information is used in this manner. (Ex. 1005, ¶[0027].)

162. Based on the premise that Alden teaches “distance data is ... used to ‘determine intensity of light that will be produced by the 61 [headlight] in the corresponding sectors,’ as shown in step 107,” Petitioner incorrectly concludes that Alden “determines illumination” for at least two subsections – inferring that Alden **uses** the distance data to **determine illumination** for a subsection. (Petition, 24.) Alden includes no such teaching. The reference never explains how it uses the distance data or even how the triangulation process determines distance (i.e., what factors it uses, what the “object” is for which triangulation is performed, etc.) Dr. Papanikolopoulos states that the “object... in this particular case is the vehicle” – without explanation or support from Alden or otherwise with respect to how the system of Alden processes two detected light sources as “the vehicle.” (Ex. 2066, 22:19-21.) To the extent triangulation requires an angle, for example, Petitioner does not explain to what point in space the angle is drawn, if “the vehicle” is

something supposedly indicated by **both** point sources. Similarly, Petitioner does not explain how distance data would be “used to ‘determine the intensity of light[.]’” (Petition, 24.) Dr. Papanikolopoulos declined to provide a detailed explanation of Alden’s triangulation during his deposition, but did conclude that triangulation is the outcome of “a pretty elaborate computer vision process[.]” (Ex. 1005, ¶[0028]; Ex. 2066, 20:8-21:22.).

163. Petitioner does not establish how Alden determines illumination **for** a subsection. Petitioner points to zones where an oncoming vehicle is present that need to be dimmed (first subsection) and zones where there is no other vehicle that should be high beam (second subsection).” (Petition, 24.) This demonstrates that what Alden determines is *which* zones need to be dimmed, which is the same determination offered for 1[C]; no separate determination is provided to establish that Alden separately determines illumination **for** a subsection. Once Alden determines the subsections that require control – i.e., element 1[C], those subsections are automatically set to the single, predetermined low beam, and the remainder of the subsections are left on high.

164. Intentionally left blank.

165. Petitioner argues that Alden only discloses two, fixed levels of illumination control – low and high, which can be seen, for example, from the footnote on page 25: “...Where Alden wants a sector of the headlight beam to be

low or high, a determination is made to power the lighting elements for those sectors to produce low or high beam intensity light, **as opposed to light at an intensity in the range between low and high.**” (Petition, 25, *see also* 24.)

166. Alden determines which zones (LEDs) should be controlled to the predetermined low intensity. Alden does not determine (or choose) low intensity illumination “for” those zones, or even choose from optional alternative illumination levels. Per the Petition: “Alden explains that **if threshold light is detected at certain sensor positions such that another vehicle is present**, a determination is made that **the intensity of light for the headlight sectors corresponding to those sensor positions should be switched to dim, or low beam.**” (Petition, 24.) Thus, the presence of threshold light triggers application of the low beam illumination level, and distance plays no demonstrated role.

167. Intentionally left blank.

168. Alden determines where detected light is located (“determined” sectors) and then provides a predetermined low illumination to the determined sectors. Regardless of the result of performing Alden’s techniques, Alden’s singular determination step does not satisfy both determination elements in claim 1.

169. Intentionally left blank.

170. Intentionally left blank.

2. Independent Claim 20

a. Claim 20[A][3]: the light sources configured to have one or more controllable light characteristics.

171. Petitioner states that “Alden discloses that its lighting elements have ‘one or more controllable light characteristics,’ as its lighting elements are ‘independently controllable as to intensity and[/or] direction.’” (Petition, 28, quoting Ex. 1005 ¶[0008].) Dr. Papanikolopoulos explained that Alden controls direction by “the placement of the LEDS with respect to the lens plus the individually controlled.” (Ex. 2066, 71:2-7.) There is no “controllability” of the direction of lighting elements in Figure 5, however. Original placement or positioning of an LED to point light in a particular direction is not a “controllable” characteristic of “direction” because it cannot be “controlled.” The remainder of Petitioner’s explanation, focused solely on how to control intensity, does not explain how direction is a “controllable” characteristic.

172. Intentionally left blank.

173. Intentionally left blank.

b. 20[C]: control circuitry configured to adjust the at least one light characteristic of at least one of the directional light sources;

174. In further support that controllable characteristics are limited to intensity, the Petition’s statements about this claim element relate exclusively to

control of intensity via the “switch arrays.” (Petition, 30.) The Petition also states that each “lighting element 119 [is] ‘individually controlled’ by a corresponding switch in the array.” (*Id.*)

175. Intentionally left blank.

- c. **Element 20[E]: The Petition fails to prove: [1] the processor, in communication with at least the sensors and the control circuitry, configured to: [2] process the sensor data to determine, within a field-of-view, at least a first subsection including a detected vehicle and at least a second subsection not including the detected vehicle ...**

176. For element 20[E], Petitioner analogously references claim elements 1[E]-1[F], stating that “Alden’s processor uses ‘sensor data’ to determine which subsections in the field-of-view include ‘a detected vehicle’ and which do not.” (Petition, 31.) However, element 1[F] is related to detecting light and creating an area to be blanked, while element 1[E] is related to sensor data predefined as pertinent to the field of view, and the explanation related to detection of “illuminated spots.” (Petition, 20.)

177. Petitioner has failed to explain how the system of Alden would determine a “second subsection not including the detected vehicle.” While Petitioner argues relative to 1[E] that data is interpreted “as headlights of a vehicle,” it offers no explanation for determining that a sector does not include a

vehicle as recited in 20[E]. (Petition, 20.)

178. Similarly, Petitioner refers back to element 1[F], but there is no mention in 1[F] related to determining where a vehicle is, and where a vehicle is not. Element 1[F] is related to a determination to reduce glare in a first subsection. Since the language of element 20[E] does not appear in either 1[E] or 1[F], Petitioner has not explained what constitutes “determination... of a second subsection not including the vehicle.” Determining where a portion of a vehicle is, based on the position of detected headlights, does not establish that the Alden system can determine where the vehicle is not, given that vehicles are larger than their headlights and can, as Petitioner notes, approach at angles where Alden’s “sectors” not including the headlights may include substantial portions of the vehicle.

179. Intentionally left blank.

180. Intentionally left blank.

181. Intentionally left blank.

182. Intentionally left blank.

3. Independent Claim 26

- a. Element 26[B]: *determining illumination requirements for the field-of-view based on the data sensed by the sensors, including determining illumination for at least a first subsection of the field-of-view including the other vehicle or***

pedestrian, as indicated by the sensor data, and for at least a second subsection of the field-of-view not including the other vehicle or pedestrian;

183. Alden does not describe determination of illumination for the subsection including the other vehicle. Alden uses a predefined low beam illumination applied to the subsections that are determined to include detected headlights.

184. There is also no determination of illumination for the second subsection – i.e., on the subsections that remain on high beam. (*Id.*) The control function of Alden is as follows: “[s]ignals are sent to each of the headlight control circuit zones that need to be dimmed to restrict the amount of current to the corresponding headlight zones such that they are dimmed in a dimming process 109. Zones which are not dimmed remain on high beam.” (Ex. 1005, ¶[0028].)

185. The Alden illumination system explained by Petitioner employs a binary high beam/low beam system. The first set of zones are determined, and those are switched to a predefined low beam setting. The remaining zones “remain on high beam.” (*Id.*) The system is designed to parse the scene and correlate zones to either a high beam or low beam level. Petitioner’s reference to 1[F] and/or 20[E] does not explain how Alden determines illumination for a first subsection including an other vehicle and at least a second subsection not including the other

vehicle as required in 26[B] (Petition, 33.)

186. Neither Alden nor Petitioner's explanation of Alden describes determining whether a subsection does "not include" the other vehicle. In Alden, to the extent any control of light outside the detected headlamp zone covers a section not including the vehicle, it happens incidentally. The system cannot "determine illumination ... for at least a second subsection ... not including the other vehicle" because it does not know what that subsection is. At best, it preserves illumination for all subsections outside the bounding box that it draws around detected light, and, as noted above, to the extent one of those subsections "does not include" a vehicle, that is simply incidental and not a determination.

187. Intentionally left blank.

188. Intentionally left blank.

- b. Element 26[C]: *determining a control strategy for controlling one or more directional light clusters in a headlight assembly to create an output headlight beam meeting the determined illumination requirements, the headlight beam spatial light distribution shaped to provide high beam illumination for a driver of the vehicle, in at least the second subsection, while mitigating glaring light illuminating at least the first subsection including detected other vehicles or pedestrians;***

189. The preceding issues with Petitioner's explanation become more pronounced when 26[B] and 26[C] are considered in concert. Alden does not

disclose determination of the illumination requirements prior to the control strategy. The “illumination requirements” – i.e., illumination for the first and second subsections – must be determined prior to the control strategy, as the control strategy is based on such determinations.

190. Alden discloses: 1) the system detects threshold illumination across a plurality of sensor elements (Ex. 1005, [0027-0028], Figs. 3,4.); and 2) based on regions where threshold illumination is present, the system compiles maps 51a, 51b each indication corresponding detected illumination. (*Id.*)

191. The system compares the maps, calculates distance to the threshold objects, and determines the “dim zones.” (*Id.*)

192. The system then “switches requisite headlight segments to dim”, i.e. to a predefined, fixed level. That is the “control strategy” for achieving dimming. This “control strategy” is also predefined as part of the predefined algorithm in Fig. 4– i.e., once the zones are known, the zones are mapped to a switch array.

193. Alternatively, if one considers determination of the bounding box to be the determination of the control strategy – although this is not clear from Petitioner’s explanation – that box is determined *before* the application of the predefined low illumination and high illumination levels. Thus, given the temporal restrictions of the “control strategy” element the determination of the bounding box *cannot* satisfy the claimed “control strategy” determination. According to the

claim, the control strategy is supposed to “meet the determined illumination requirements,” but if the argument of “illumination requirements” does not occur in Alden until *after* the bounding box is determined, then determination of the bounding box cannot “meet” such “determined illumination requirements.”

194. Intentionally left blank.

195. Petitioner has failed to explain how Alden discloses elements 26[B]-[C], including how the illumination requirements for the subsections are “determined,” or how a control strategy that “meets determined illumination requirements” can be determined for illumination requirements that are determined after the alleged control strategy.

196. Intentionally left blank.

197. Intentionally left blank.

198. Intentionally left blank.

199. Intentionally left blank.

200. Intentionally left blank.

4. Dependent claim 2

- a. **Element 2[B]: *one or more light emitting sources, each having a variable light-source characteristic dependent on power, and wherein the control circuitry is arranged to alter said light-source characteristic via power control;***

201. Petitioner relies on Alden’s lighting elements 119 as disclosed with

reference to Figure 5 for satisfying “*light emitting sources*” in element 2[B]. (Petition, 38.) For the “*light source characteristic*” of each light source (collectively, “the characteristics”) “dependent on power”, Petitioner relies on Alden’s disclosure in Paragraphs [0026]-[0029], and states that “the intensity of each light element is alterable, as it can be either a ‘high’ or ‘low’ beam.” (Petition, 38.) Thus, the explanation relies on the “*characteristic*” being intensity.

202. Intentionally left blank.

203. Intentionally left blank.

b. Element 2[C]: *one or more light modifying elements provided in the path of light emitted from at least one of the sources, further controlling the light-source characteristics*

204. Petitioner relies on Alden’s lens 121 as described in ¶[0029] and Figure 5 for satisfying the “*light modifying elements*” limitation. (Petition, 39.) Alden discloses that the light element “119 and other lighting elements are on a curve along the focal point of a headlight lens 121 such that the light from each lighting element goes into a specified portion (or portions) of the headlight distribution area.” (Ex. 1005, ¶[0029].) Thus, Alden discloses that the lens 121 adjusts the direction of light emitted by the light element 119, not its intensity. Given the interrelationship between claim elements 2[B] and 2[C], lens 121 does not “control” the intensity characteristic, as required by the claim. Accordingly,

Petitioner's 2[B] and 2[C] explanation does not show how Alden discloses *“wherein the control circuitry is arranged to alter said light-source characteristic via power control; [and] one or more light modifying elements . . . further controlling the light-source characteristics”* as claimed.

205. Petitioner further states that “[i]n addition, Alden’s system can include other ‘light modifying elements,’ including a ‘variable refractive element’ in the form of a liquid crystal. (Alden, [0033]-[0035], [0061], Figs. 8-10.)” (Petition, 40.) Petitioner proposes modifying Alden’s Figure 5 embodiment to include Alden’s refractive elements of its Figure 8-10 embodiments stating: “Alden discloses that its use of refractive elements to ‘bend’ light can be included in its headlight system, such as that of Figure 5, and a POSITA would have readily understood how to implement the variable refractive elements in such system. (*Id.*, ¶97.)” (Petition, 42.) Alden does not disclose combining the Figure 5 LED, “first embodiment” with the “third embodiment” depicted in Figures 8-10. Rather, Alden discloses three distinct embodiments, having a different principle of operation to control either intensity or the direction of light exiting the headlights. Further, Alden’s ¶61 (e.g., “Many other variations are possible”) does not support Petitioner’s proposed combination.

206. The Petition does not explain why a POSA would have made the proposed substitution, as well as how a POSA would have combined Alden’s

Figure 5 and Figures 8-10 embodiments. In his deposition, Dr. Papanikolopoulos explained, for the first time, how a combination might be made—proposing the insertion of a single electro-optic refractor close to the first LED element of the Figure 5 embodiment between the LED array and the lens 121:

Q. Okay, so how would a POSITA have added this refractor element to the Figure 5 embodiment?

A. So, for example, let me go to figure -- so let's suppose, for example, if you go to Figure 5, . . . So the element -- the first element from the top, the first LED element, we can put a refractor, which is basically it's quite small, we can put it as close to the LED as possible, among other options.

(Ex. 2066, 79:3-16.)

Q. Okay, so you're inserting this [one refractor element] . . . to the Figure 5 embodiment between the LEDs and the lens 121 or are you removing lens 121?

A. A POSITA will have the option depending on the particular task but in this case in this scenario that I mention in the context I mention before, **we can keep the lens.**

(Ex. 2066, 80:11-17.)

207. Petitioner states, “a POSITA would have had a reasonable expectation of success, as the refractor would perform its same function of allowing light to pass straight through when a circuit is open and bending light when the circuit is

closed.” (Petition, 42.) This statement, however, ignores the express teachings in Alden regarding the third embodiment, depicted in Figures 8-10, which shows collimated light entering the electro-optic elements at the same perpendicular angle and the fact that the liquid crystal is described as “birefringent.” (Ex. 1005, ¶¶33, 51.) However, LEDs do not provide collimated light.

208. Use of an electro-optic refractor in the lamp of Figure 5 would result in most light striking the refractor at non-perpendicular angles. Such birefringent crystal would effectively scatter such light and would not work with the embodiment of Figure 5. Accordingly, the proposal to add the elements of Figures 8-10 to the system of Figure 5 is not explained sufficiently to ensure a reasonable expectation of success – as a POSA would be uncertain whether the combination as proposed would produce an operative headlamp beam.

209. Intentionally left blank.

210. Intentionally left blank.

5. Dependent claim 3

- a. **Element 3: *wherein the one or more light modifying elements is at least one of a static light modifier or a variable light modifier, said light modifying element comprising at least one of reflectors or refractors, and wherein variable light modifier*** control circuitry is configured to control the light-cluster light characteristic by altering the light modifying elements in the path of the light emitted from the at least one of the light

sources.

211. Claim 3 depends from claim 2. Petitioner relies on lens 121 as described in ¶[0029] and Figure 5 for satisfying the “*light modifying elements*” of claim 3. Because lens 121 is a static light modifier not capable of controlling intensity, the “characteristic” fails to meet the claim 2 limitation. Per claim 2, the “*light-source characteristic*”—which Petitioner identifies as “intensity”—must be “*dependent on power*” and capable of being altered “*via power control.*” Furthermore, the “*light modifying element*” must control “*the light source characteristics.*” (Petition, 38) While intensity of individual LEDs is capable of being altered via power control, static lens 121 is incapable of controlling intensity.

212. The Petition does not identify or explain any other characteristic, such as direction, dependent on power and controllable by lens 121.

213. Intentionally left blank.

214. The Petition does not explain how Alden’s switch arrays 51a, 51b of Figure 3 could be controlled or modified to control both an array of switches having corresponding LEDs in combination with an array of electro-optic elements as disclosed in Figure 8, likely different in number and required control signals relative to the LEDs.

215. In the Alden embodiment of Fig. 10, the control circuitry controls the electro-optic elements, the light source is a static single-point emitter that would be

powered to maximize high beam areas within the distribution pattern. (Ex. 1005, Fig. 10.) In contrast, in the embodiment of Figure 5, the control circuitry individually controls power to the plurality of light sources of the LED array. (Ex. 1005, Fig. 5.) Neither the Petition nor Alden explains how the control circuitry of Figure 3 would be utilized or modified to coordinate control of the multiple LED light sources in addition to an array of electro-optic elements.

216. Intentionally left blank.

217. Intentionally left blank.

218. Intentionally left blank.

219. Intentionally left blank.

- 6. Dependent claim 4: *headlight system of claim 2, wherein the light modifying element further comprises at least one of lenses, diffractors, optical devices, a light guide, filters, phosphors, optical coatings, prisms, controllable piezoelectric light guides, MEMS devices, light valves or optical switches***

220. The lens of claim 4 fails to satisfy all claim limitations inherited from claim 2 as noted above with respect to claim 2 because, as noted with respect to claim 3 above, the “light modifying element” needs to control a light source characteristic “dependent on power” and Petitioner has never shown how direction, controlled by the lens, is a characteristic dependent on power. (Petition, 45.)

221. The variable refractive element combination discussed with respect to

claim 2[C] includes the deficiencies noted with respect to the claim 2[C] combination. Thus, this explanation also fails for the reasons presented with respect to claim 2[C]. (Petition, 45.)

222. Intentionally left blank.

223. Intentionally left blank.

- 7. Dependent claim 11: *headlight system of claim 1, further including a computer vision processing unit configured to use the sensor data and one or more of the algorithms to identify entities including at least one of beings, vehicles, roadway, or street signs and wherein the logical controller/processor is further configured to modify the headlight beam to change illumination of the identified entity***

224. Alden detects light above a predetermined threshold but fails to disclose identifying vehicles (or anything else). Alden functionally determines an area in which light should be diminished, based on the detection of light within that area and making some accommodation around the light in the form of a bounding box. At no point does Alden have an algorithm, for example, that “identifies” a vehicle in any manner.

225. Intentionally left blank.

226. Intentionally left blank.

- 8. Dependent claims 15, 21, 32-33**

- a. Claim 15: system of claim 1, wherein the logical controller is further configured to *determine at***

least a road curvature, indicated by the sensor data, ahead of the vehicle and wherein the required illumination includes increasing illumination in a direction of the road curvature

227. Petitioner combines the explanations for claims 15 and 21. (Petition, 52.) However, these claims have variations in language identified by the italicized phrases and associated deficiencies addressed separately.

(1) **wherein the logical controller is further configured to *determine at least a road curvature, indicated by the sensor data, ahead of the vehicle***

228. There are several requirements for this portion of claim 15: a) that the logical controller determines the road curvature; b) that the road curvature is indicated by “the” sensor data; c) that the road curvature is “ahead” of the vehicle. “The sensor data” is claimed as “data predefined as pertinent to illumination requirements of the field of view.” The explanation for “sensor data” in claim 1 was “detected light.” Thus, the road curvature “indicated by **the sensor data**” must be also based on detected light – or, alternatively, different sensor data must be shown to meet the “predefined as pertinent to illumination requirements” limitation of 1[E].

229. The Petition contends that “Alden discloses that a vehicle with the ‘segmented sensing elements and segmented light distribution elements described herein’ can ‘sense[] that the road turns by receiving light from reflectors such as

reflector 157.” (Petition, 53 citing Ex. 1005, ¶[0036].) In his first deposition, however, Dr. Papanikolopoulos expressly stated that the “reflectors” would appear in “the same manner as headlamps” and that the system would use the “same logic.”

A. So basically here what is happening, when there is a detection like this, Alden, by using the LEDs described in figure 5 and the corresponding paragraph, makes this dim while the other has full light in order to increase the visibility for the driver. In figure 11, I believe, the same structural figure 5 can do the dual (phonetic). **In other words, I can have dots of the reflectors -- instead of having the dots that correspond to the headlights, I have dots that correspond to the reflectors on the side of the road.** So I want to -- as we drive, we want to be able to see this better. So it's going to send as much light as possible to this one by using the same structure.

Q. Okay.

A. So it's the dual problem. Again, one is actually high beam so I don't create glare for the oncoming driver, or **if I'm on a turn the system can use these refractors (sic) by using the same logic of detecting lights** -- using the same reflectors in order basically to just have direct LED light in order for the driver to make inferences about the curvature.

(Ex. 2066, 78:16-79:15, emphasis added.)

When pressed further, Dr. Papanikolopoulos explained:

Q. So using the figure 5 embodiment you're saying that light reflects off these reflectors on the side of the road and the headlamp detects these and then dims those corresponding lights?

A. No. What I'm saying is the following: **There are two main use cases in Alden. One is basically headlights maximizing visibility for the driver and minimizing – we discussed this. The second one is actually using the same logic, which is described in figures 3, 4, and 5. I detect that, so my dots here in the figure 3 are going to be the reflectors. The reflectors are going to be something that corresponds -- it will have the same appearance on the image like the headlights. So I will have a rectangle like -- but instead of having dim light I'm going to have high beam ...**

(Ex. 2066, 79:18-80:12, emphasis added.)

230. Alden does not teach any logic for determining the difference between headlights and reflectors, and as Dr. Papanikolopoulos notes, he understands the reflectors to “have the same appearance on the image like the headlights.” (Ex. 2066.)

231. Without being able to determine the difference between vehicles and reflectors, Alden does not disclose how to respond to the detected light from reflectors compared to detected light from oncoming vehicle lights or how to produce some form of “concentrated” high-beam emission. Consequentially, it is not apparent that Alden actually has sufficient teachings to enable the embodiment

of Fig. 11 specifically in regards to determining what detected light is a reflector indicative of a curve, and warranting curve-emission (, versus what is indicative of a vehicle, warranting glare reduction.

232. Petitioner contends that “this data” (detected light) is used to “adjust the LEDs ‘responding headlights 155’ so that they ‘direct light into the corner ...’ (Petition, 53.)

233. Because Alden does not disclose how to distinguish between the two varied light-sources, and Petitioner has interpreted Alden as reading the two sources “in the same manner” such that reflectors “appear like headlights,” Alden’s system would not be capable, without modification, to determine the presence of a curve based on detected reflection.

234. Petitioner relies on Alden’s steering wheel rotation sensor as providing “the sensor data”. (Petition, 53). Petitioner’s interpretation is inconsistent with the previous interpretation of “the sensor data” from claim 1 – i.e., “data predefined as pertinent to illumination requirements of the field of view.” Even assuming that the steering wheel rotation sensor data satisfy the claim limitation, the steering data is not indicative of a road curvature “ahead of” the vehicle.

235. “Pre-steering” into a turn does not solve this, because if slight movements of the wheel caused the system to anticipate a turn, then slight changes

to steering such as during lane changes that do not indicate a curve is present or upcoming would result in illumination changes. (Ex. 1005, ¶[0040].)

236. Intentionally left blank.

237. Intentionally left blank.

238. Intentionally left blank.

(2) *wherein the required illumination includes increasing illumination in a direction of the road curvature*

239. It is not clear that the headlight of Figure 5 can “change direction.” (Petition, 53.) The lamp already emits high beams everywhere there is not glare reduction and it lacks any optical or mechanical steering. (Ex. 1005, Fig. 5, ¶¶[0006], [0026]-[0027].)

240. Further, in his deposition, Dr. Papanikolopoulos opined that the array already includes LEDs positioned to cover curves:

Q: So farther down below in that paragraph, you have a sentence here, “Further a POSITA would have understood from Alden that when positioning LEDs along the curve structure in the headlamp, such as shown in Figure 5, LEDs could be positioned to ensure that the beam created by the headlamp is sufficiently wide to illuminate turns.” Do you see that?

A:Yes.

Q: Are you proposing adding additional LEDs to what’s shown in Figure 5

or are you saying that's what is shown in Figure 5?

A: I say such as shown in Figure 5.

(Ex. 2026, 111:18-112:5)

And, in another deposition, Dr. Papanikolopoulos admitted that when there are no other vehicles present, all LEDs are emitting:

Q: Okay, but in normal driving conditions when there's no oncoming traffic and no curves, the Figure 5 embodiment would illuminate the full pattern shown in Figure 5, is that correct?

A: Yes.

(Ex. 2067, 17:21-25.)

241. While the second question stated that there were “no curves,” the first question establishes that, were there curves, such a light, operating with all high beams is “sufficiently wide to illuminate turns.” So, a POSA would understand that were a curve to appear ahead of the vehicle, it would have already been illuminated by the “sufficiently wide” pattern achieved by illumination of the “full pattern shown in Figure 5.”

242. The embodiment of Figure 5 has not been shown to “increase” illumination as claimed, and it already includes sufficient LEDs to “ensure that the beam created by the headlamp is sufficiently wide to illuminate turns.”.

243. Intentionally left blank.

244. Intentionally left blank.

9. ***Claim 21: system of claim 20, wherein the processor is further configured to determine at least a road curvature, indicated by the sensor data, ahead of the vehicle and to direct the control circuitry to adjust the directional light sources to increase illumination in a direction of the road curvature***

a. ***wherein the processor is further configured to determine at least a road curvature, indicated by the sensor data, ahead of the vehicle***

245. The deficiencies of Petitioner's explanation for this limitation are essentially the same as those previously described with respect to claim 15. Furthermore, Petitioner does not provide any explanation for how or why Alden would be modified to meet this limitation.

b. ***to direct the control circuitry to adjust the directional light sources to increase illumination in a direction of the road curvature***

246. This limitation varies slightly from that of claim 15, requiring that the processor direct control circuitry to adjust directional light sources. In addition to deficiencies noted above with respect to claim 15, Petitioner does not describe what the adjustment would be that achieves an increase of illumination in a direction of the road curvature. While Alden indicates that the steering may be used to change in illumination of "f(x)" degrees, Petitioner does not explain how the processor of the claim 20 explanation directs the control circuitry of the claim 20 explanation to increase illumination f(x) degrees or in any other manner.

247. The blended argument contends, for example “This data [sensed turns from reflectors is] used by the CPU and control circuitry to adjust the LEDs ‘responding headlights 155’ (such as, for example, those show in Figure 5 pointed in the direction of the reflectors) so that they ‘direct light into the corner....’” (Petition, 53.)

248. With regard to Figure 5, Alden clearly states that all LEDs “remain on high beam” and further, Dr. Papanikolopoulos already stated that Figure 5’s LEDs are sufficient to ensure that curves are illuminated. (Ex. 2067, 111:18-112:5.) It is also unclear what such “adjustment” would encompass, since the LEDs are already operating at high beam. Accordingly, there is no showing of how control circuitry is “directed” to adjust directional light sources, and the explanation fails for at least this additional reason.

249. Intentionally left blank.

250. Intentionally left blank.

10. Claims 32/33

251. Petitioner’s explanation for these claims conflates curves and turns, even though the claims plainly distinguish between the two consistent with the ordinary meanings of curves and turns. Lighting for a turn is different from lighting for a curve.

252. Petitioner’s explanations for claims 32/33 have the same deficiencies

as addressed with respect to claim 15 -- the vehicle is incapable of distinguishing between headlights and road reflectors.

253. Intentionally left blank.

254. Intentionally left blank.

255. Intentionally left blank.

11. Dependent claims 16-17, 22-23, 34-36

a. Claims 16/17

256. These claims also indicate a “turn” instead of a “curve” and claim 16 depends from a claim that expressly claims a “curve.” Petitioner never explains whether or why the difference is immaterial.

257. And again, because Alden discusses determining the “new direction” of the vehicle with respect to the steering function $f(x)$ and not the “planned new direction” as Petitioner contends, turning a steering wheel while the vehicle is not moving will have no apparent effect, as there is no “new direction” of the vehicle at that moment. (Petition, 55.)

258. Intentionally left blank.

259. Intentionally left blank.

12. Claims 22/23

260. Again, the claims relate to a planned turn, not an upcoming curve, and the explanations do not vary. These explanations are deficient for the reasons cited

with respect to claims 15/21 and with respect to claims 16/17 and 33.

261. Intentionally left blank.

262. Intentionally left blank.

13. Claims 34/36

263. In addition to all of the shortcomings related to “turn” vs. “curve” noted above with respect to claims 15/21 (enablement) and claims 16/17/33 (turn vs. curve), the claims also recite determining control instructions for controlling a light source to “achiev[ing] illumination of the turn” – another distinction never shown or explained by the mere analogy to claims 16-17 and 32-33.

264. Intentionally left blank.

14. Claim 35

265. Again, this claim is about a turn, and the explanation suffers from all the issues of claims 15/21 and 16/17/33. Further, the claim now calls for “creating an output headlight beam” that illuminates the turn, a particular feature never explained by Petitioner with respect to the analogous rejections.

266. Intentionally left blank.

267. Intentionally left blank.

B. Ground II – Alden in view of Harbers

1. **Claim 5:** *wherein at least one of the light-clusters includes: [a] a plurality of light sources, wherein one or more of the plurality of light sources comprises at least one of multiple light-emitting-diodes (LEDs) or organic*

light-emitting-diodes, [b] each light source having a spectral power distribution characteristic and wherein the control circuitry is configured to alter the overall light-cluster spectral power distribution to illuminate at least one of the at least two sub-sections of the field-of-view with a different color of light from another of the at least two sub-sections

- a. **5[a]:** *wherein one or more of the plurality of light sources comprises at least one of multiple light-emitting-diodes (LEDs) or organic light-emitting-diodes*

268. Claim 5 requires a light cluster including a plurality of light sources, with at least one of those light sources comprising multiple LEDs or organic LEDs. Petitioner's explanation shows neither a single light source of a cluster including multiple LEDs, nor a single light source being an organic LED. (Petition, 60.) Petitioner's explanation about clusters, rather than an individual light source, with respect to Alden and Harbers does not meet the limitations of Claim 5.

269. Intentionally left blank.

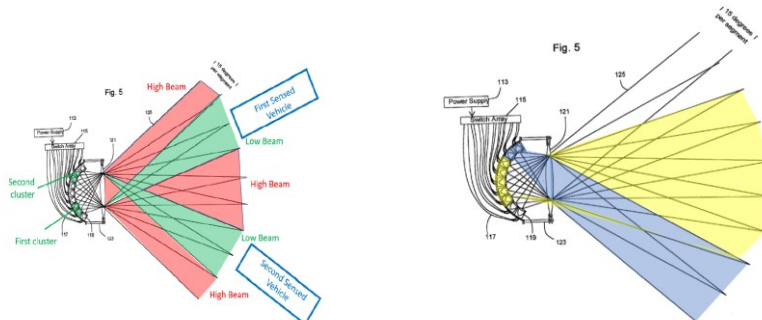
270. Intentionally left blank.

- b. **5[b]:** *...wherein the control circuitry is configured to alter the overall light-cluster spectral power distribution to illuminate at least one of the two sub-sections . . . with a different color of light—*
- c. **Reliance on single colored LEDs would cause colored emission from the combination**

271. Petitioner relies on the colored LEDs of Harbers to teach this claim

limitation. (Petition, 61.) Specifically, Petitioner notes that the LED array may include red, green, blue and yellow LEDs. (*Id.*) Petitioner does not explain how including such LEDs into the system of, for example, Fig. 5 of Alden will not create color changing issues with emission. Petitioner has not explained how or why the nine-LED embodiment of Figure 5 would be modified by the different color LEDs of Harbers. (*Id.*)

272. Harbers discloses a system with each beam segment having a defined function (e.g., high, low, fog, etc.), not a portion of the field of view. However, as shown in some of Petitioner's examples reproduced below, oncoming vehicles may be traveling towards the emitting vehicle at angles. Since, in those examples, the whole beam of a one or two LEDs encompasses that vehicle, that vehicle would see red, or yellow, or blue, etc., or at least light half comprised of that color. Also, in the example shown below in Petitioner's annotated figure from another Petition, the driver's face would be squarely in the "blue" beam proposed for the annotated figure in this argument.



(IPR2023-01039, 49.)

273. Based on Alden’s configuration, each LED has a certain specific responsibility. (Ex. 1005.) Any vehicle, or driver’s face, within that area of responsibility, would see the color of light aimed at that portion.

274. Harbers notes expressly that its specific color ordering is important. “By ordering the LEDs in the manner indicated in Fig. 2, a substantial reduction of possible color effects is achieved...” (Ex. 1006, 8:30-34.) Petitioner has never explained, for example, what effect on color would be achieved by dimming a single (or group of) color LEDs, or replacing white LEDs, having exclusive responsibility for a sector, with colored ones, rendering the combination unpredictable and unsuitable.

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2. Claim 28

277. Claim 28 requires color of light output for certain regions, such as

bluish illumination along a roadside and yellowish illumination in the center of the road. Again, Petitioner relies on inclusion of “color” LEDs. (Petition, 65-66.) Petitioner does not explain how a POSA would address the unpredictability selective dimming would have on such a system, and/or the issues occurring from not following Harber’s strict LED pattern to “substantially reduce possible color effects.” Petitioner has therefore not described a suitable motivation to combine these references in the manner proposed.

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279. Intentionally left blank.

3. Claim 29

280. Petitioner again relies on usages of colored LEDs. (Petition, 67). Changing output levels of LEDs and “activating different LEDs,” functions of Harbers imported into Alden to deal with creation of function-specific beams, has not been shown to be compatible with the general system of Alden. Even more so, with a one-dimensional array, it is not even clear how such changing would occur – where each element is singularly responsible for a given segment of the scene. Petitioner, however, never expands the array, in any explanation, beyond the single row. Accordingly, this combination suffers from all the deficiencies of the proposals with respect to claims 5 and 28, as well as generally being non-functional for its intended purpose, being limited to one row of LEDs.

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C. Ground III – Alden in view of Bergkvist Claim 6 (inclusion of UV LED)

282. For this combination, Petitioner relies on the inclusion of “a UV light source” “in the array of Alden” based on Bergkvist. (Petition, 69.) Bergkvist uses a single light source that emits in both visible and UV spectrums. (Ex. 1007, 2:63-28.) Bergkvist relies on a filter to block visible light. (*Id.*, 3:17-26). Bergkvist has no LEDs, nor does it mention UV LEDs. The suggestion to “include at least one UV light source in the array of Alden” has no motivation in Bergkvist, as there is no filter element imported – i.e., incorporating the source of Bergkvist will simply also produce visible light. (Petition, 69.)

283. Petitioner also provides no explanation as to how any UV light will be in a sector without visible light, which is the stated motivation to combine. The Bergkvist light source produces both visible and UV light and without the filter of Bergkvist, anywhere there is UV light, there would be visible light. Since the motivation to combine was “in order to have light outside the visible range, such that it is not distracting to other drivers or pedestrians” it is unclear how such distraction would not occur when visible light is not filtered.

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D. Ground IV – Alden in view of Beam

286. This claim limitation relates to detecting a preceding vehicle (i.e., taillights). Petitioner largely seems to simply be importing the idea that if one can detect headlights, one can also detect taillights. (Petition, 72.) Based on deposition testimony, Dr. Papanikolopoulos. seems to believe that all the requisite capability is present in Alden, and that one would simply tune the sensor of Alden to detect taillights. (Ex. 2066, 4: 4-17.)

287. Beam provides no such tuning, it simply relies on detecting light that is indicative of both headlights and taillights. (Ex. 1008.) Presumably, for example, the system Alden, so modified, would have its threshold tuned downward to include the data of taillights (dimmer than headlights). Problematically, however, this would, for example, increase the level of illumination detected for an oncoming headlight – by decreasing the threshold of detection, more light from an oncoming headlight would be detected, so the “spots” would be bigger. Since Alden never exactly explains how it pairs lights, it is unclear of the overall effect this plan would have on the control system.

288. Further, a traveling vehicle on a crowded highway would see countless preceding taillights, and there is no concept of how the system of Alden would “match” such lights across two sensors, especially given that all would appear much dimmer than headlights and distinguishing between various pairs

would be even more difficult. Beam does not attempt sensor-to-sensor matching. While Beam still has the problem of pairing lights within a single sensor, at least it does not have to match the data between two sensors.

289. The matching of taillights across sensors would be rendered significantly difficult, if not impossible, were more than a few vehicles present, and in either event, Alden never explains such matching for anything more than a single vehicle scenario.

290. This combination seems to be borrowing nothing from Beam other than, perhaps, a tuning of a threshold to receive more light from **all** sources. Moreover, in light of the potential correspondence problem – i.e., matching the data across two sensors as required by Alden, it seems that a great deal of additional modification and/or experimentation would be needed to also accommodate preceding taillights.

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E. Ground V – Alden in view of Kobayashi

293. For this limitation, Petitioner imports the GPS of Kobayashi. (Petition, 75.) The combination, as explained, however, seems to be an either/or type of combination, without explanation as to which system controls when both signals are useful. That is, even if GPS coordinates are present, the combined system

seems to only use them when reflectors are not present. (Petition, 77.) Petitioner's explanation about "urban environments" ignores the well understood "urban canyon" issue with GPS – that when you are in an urban environment, you frequently lose accurate GPS signals – so to the extent that the motivation was to address places in urban environments where it was impractical to install reflectors, it was comparably impractical to rely on GPS in those locations.

294. Moreover, this ignores the larger issue, which is that Alden's system is already inclusive of a significant beam-spread, more than sufficient to accommodate curves. (Ex. 2066.) And, Alden lacks any control over its LEDs for curve purposes – they emit, per Alden, at high-beam all the time, and there is no way to "control" them alternatively to deal with curves. Granted, claim 5 requires nothing more than inclusion of a GPS sensor, but in light of the preceding issues, there is not actually a reason to include such a sensor from Kobayashi, as Alden's Fig.5 system can do nothing useful with GPS data.

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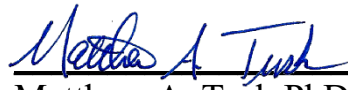
XI. Conclusion

297. In my opinion, the prior art references discussed above taken alone or in any permissible combination do not disclose or suggest each and every element of the challenged claims.

298. I reserve the right to supplement my opinions to address any information obtained, or positions taken, based on any new information that comes to light throughout this proceeding.

I declare under penalty of perjury that the foregoing is true and accurate to the best of my ability.

Executed on: April 10, 2024



Matthew A. Turk PhD