UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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MERCEDES-BENZ USA, LLC
Petitioner,

v.

YECHEZKAL EVAN SPERO
Patent Owner.

_____

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

IPR Case No.: IPR2023-01027

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

TABLE OF CONTENTS

List of Declaration Exhibits 5
I. Qualifications and Professional Experience 9
II. Relevant Legal Standards 16
III. State of the Art as of 2002 18
A. POSA Considerations for LED Forward Lighting 18
B. Regulations and Standards 18
C. Design Tradeoffs 24
D. Hardware 30
E. Optical System 31
F. Spatial Light Modulator 34
G. Heat management 37
H. Packaging 39
I. Cost 40
J. Detection and Classification of Vehicles 41
IV. Overview of the '503 Patent 43
V. The Challenged Claims 46
VI. Qualifications of One of Ordinary Skill in the Art 50
VII. Proposed Claim Construction 52
VIII. Overview of the Prior Art 52
A. Alden 52
1. Alden's disclosure is theoretical 60
2. Alden's three discrete embodiments are not combinable 74
B. Harbers 82
C. Bergkvist 85
D. Beam 85
E. Kobayashi 91
F. Stam 95
G. Braun 96
IX. Alden's disclosure requires speculative interpretation or modification to operate as described in the Petition 96
A. Alden does not anticipate the challenged claims 96

B. Dr. Papanikolopoulos testified that Alden's Figure 5 embodiment is inoperative without modification 101

X. Grounds for Challenge.....104

A. Ground 1: Alden Fails to anticipate at least certain limitations of claims 37-44, 47, 50-56, 58-59, 60-62, 64-65 and 70 104
1. Independent Claim 37 104
2. Independent Claim 59 112
a. 59[D]: *wherein the at least one processor is configured to: determine light output . . . the illumination aimed at the first subsection substantially resulting in light below a first predefined illuminance in the first subsection*.....112
3. Independent Claim 65 115
B. Grounds II-V: All Obviousness Combinations 136
C. Ground II – Alden in view of Harbers 136
1. Claim 45: *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 alterable, at least responsive to instructions from at least one of the at least one processors, by modifying power to the one or more light sources of the plurality of light sources, resulting in a color change to projected light from the at least one light-cluster illuminating at least one sub-section of the field-of-view.* 136
2. Claim 68: *wherein the determining illumination further includes determining a yellowish illumination color for illumination illuminating a road within the field-of-view and a blueish illumination color for illumination illuminating areas off-road within the field-of-view*.....138
3. Claim 69: *wherein the data includes data indicating fog or snow environmental conditions and the determining illumination includes determining a shift of at least a portion of the light output from the headlight system towards yellow* 139
D. Ground III: Alden in view of Bergkvist 140

1. Claim 46: *wherein the light output from at least one headlamp further comprises at least one of infrared or ultraviolet wavelengths* 140
E. Ground IV: Alden in view of Beam 141
1. Claim 48: *wherein at least one of the sensors is a camera-sensor configured to image at least lights indicative of a preceding vehicle* 141
F. Ground V: Alden in view of Kobayashi 142
1. Claim 49: *wherein the one or more sensors further includes a GPS sensor* 142
G. Ground VI: Alden in view of Braun 143
1. Claim 66: *wherein the data includes data indicating a pedestrian and wherein the determining illumination includes determining an illumination level, for at least a third subsection including the pedestrian* 143
2. Claim 67: *wherein the data includes data indicating a road-sign wherein the determining illumination includes determining an illumination level, for at least a third subsection including the road-sign.* 144
XI. Conclusion 145

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*
2041	Transcript of Deposition of Nikolaos Papanikolopoulos, Ph.D. *Mercedes Benz-USA, LLC v. Yechezkal Evan Spero*, 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, *Handbook of Optics* 3RD 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-

Exhibit No.	Description
	papers/content/2004-01-0434/)
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, *Handbook of Optics* 3RD 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.)
2062	Texas Instruments "Introduction to +/- 12 Degree Orthogonal Digital Micromirror Devices (DMDs)

Exhibit No.	Description
	(Available at https://www.ti.com/lit/an/dlpa008b/dlpa008b.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-wwe&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 2nd Edition excerpts, Simon and Schuster (1983)
2066	Transcript of Deposition of Nikolaos Papanikolopoulos, Ph.D. *Mercedes Benz-USA, LLC v. Yechezkal Evan Spero*, taken on March 26, 2024, IPR2023-01026, IPR2023-01027
2067	Transcript of Deposition of Nikolaos Papanikolopoulos, Ph.D. *Mercedes Benz-USA, LLC v. Yechezkal Evan Spero*, 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

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. 2050[1] 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

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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. 2051[2] 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. 2052[3] 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

> 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 mm^2.

(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. 2053[5] 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. 2060[6], 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. 2061[7].) 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. 2062[8].)

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:

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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-wwe&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. 2055[9] 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. 2056[10] 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. 2063[11], 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.)

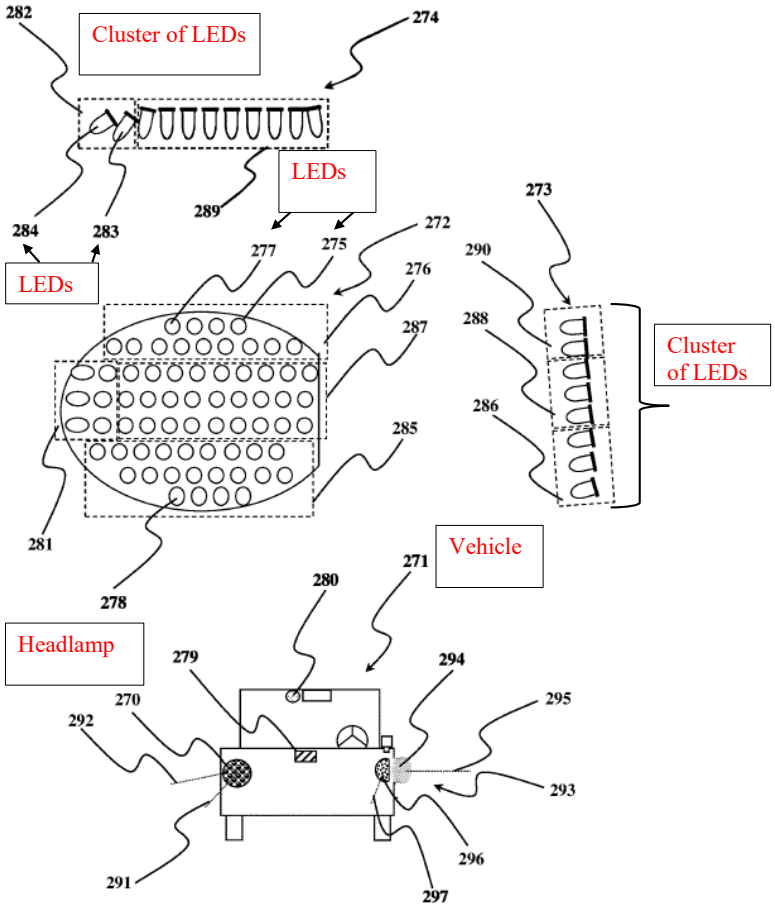
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true and accurate copy of a technical paper that I understand was published by IEEE in March 2002.

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 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. 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 54, 60, 55, 56) and, identifying vehicles or determining the position of vehicles (claim 50).

V. The Challenged Claims

56. The Challenged Claims are claims 37-70. Claims 37, 59, and 65 are independent claims and are reproduced below. All other Challenged Claims depend directly or indirectly from one of those independent claims.

[37.P] A vehicle headlight system comprising:
[37.1] one or more headlamps affixable to a first vehicle;
[37.2] a plurality of light clusters arranged in each of the one or more of the headlamps and
[37.3] capable of illuminating sub-sections of a field-of-view with different

illumination characteristics,
[37.4] wherein at least two of the light clusters operate to create a headlight beam;
[37.5] one or more sensors configured to obtain and provide sensor data,
[37.6] at least a portion of the sensor data indicating a second vehicle within the field-of-view; and
[37.7] at least one processor configured to: receive the sensor data; process the sensor data to determine a light distribution pattern for an adaptive headlight beam,
[37.8] such that a headlight beam adapted to the pattern substantially illuminates a first subsection of the field-of-view including at least a portion of the second vehicle with an illuminance below a predefined threshold value,
[37.9] while the beam substantially illuminates at least the one or more second subsections of the field-of-view to either side of the first subsection with an illuminance above the predefined threshold value; and
[37.10] instruct operation of at least two of the light clusters to create the adapted headlight beam.

[59.P] A vehicle headlight system, comprising:
[59.1] one or more headlamps affixed to a first vehicle;
[59.2] each headlamp including at least three directional light sources having different aimings relative to the first vehicle,
[59.3] the light sources having one or more controllable illumination characteristics;
[59.4] one or more sensors configured to sense information,
[59.5] at least a portion of the sensed information indicating a second vehicle, and
[59.6] communicate sensor data reflecting the sensed information to at least one processor,
[59.7] wherein at least one processor is configured to: process the sensor data to identify a first subsection, of a field of view, that includes at least a portion of the second vehicle;
[59.8] determine light output for the headlight system that aims illumination at the first subsection;
[59.9] the illumination aimed at the first subsection substantially resulting in light below a first predefined illuminance in the first subsection, and
[59.10] that aims illumination at one or more subsections of the field of view

to either side of the first subsection,
[59.11] the illumination aim at the one or more second subsections substantially resulting in light above the first predefined illuminance in the one or more second subsections; and
[59.12] instruct adjustment of one or more of the light sources to achieve the determined output.
[65.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:
[65.1] utilizing one or more sensors of a first vehicle to obtain and provide data, the data including data indicating at least a second vehicle;
[65.2] determining illumination for at least a first subsection including the second vehicle and at least one or more second subsections, to either side of the first subsection, including determining an illumination level for the first subsection below a predefined illuminance, and determining an illumination level for the one or more second subsections that substantially illuminates the one or more second subsections above the predefined illuminance;
[65.3] determining control instructions for controlling one or more

directional light sources included in the adaptive headlight system to achieve the determined illumination levels for at least the first and one or more second subsections; and
[65.4] controlling the light sources to emit the headlight beam in accordance with the control instructions.

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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 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, 4-5.)

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.

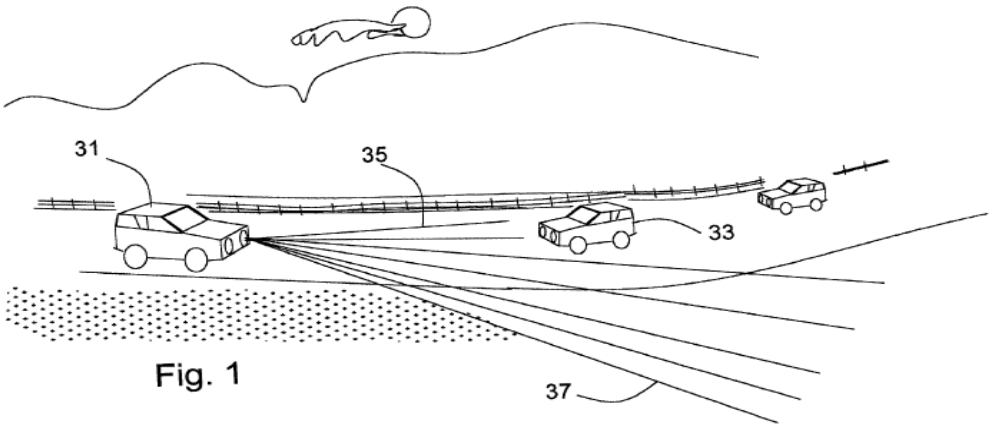
65. The plain meaning of a “turn” is a “change of direction when moving” (www.google.com/turn) while the plain meaning of a “curve” is a “continuously bending line, without angles.” (https://www.dictionary.com/browse/curve). Thus, by their plain meanings alone, a “curve” lacks the “angle” that facilitates 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 various headlights produce individually controllable beam segments, 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. (*Id*., ¶¶[0027-0028], Fig. 3.) Central processing unit (CPU) 71 determines whether incoming light detected in each sensor sector has a threshold intensity. (*Id*.)

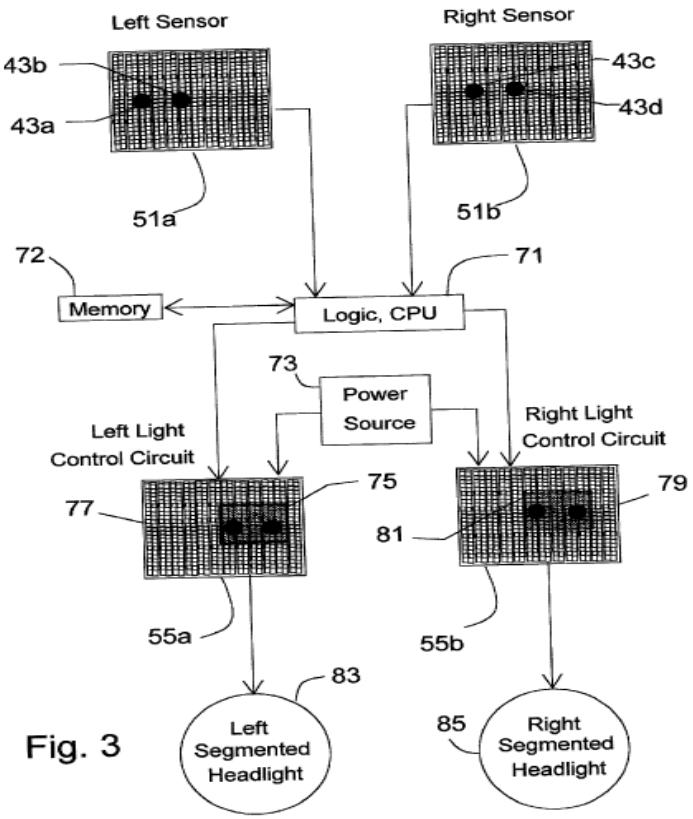
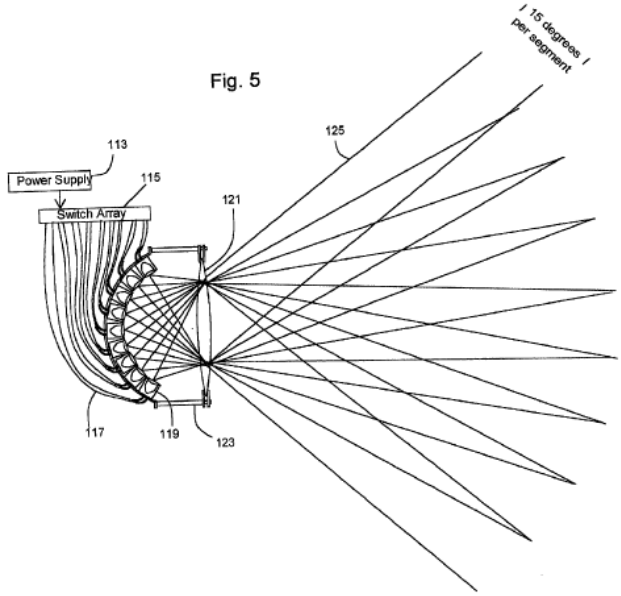


Fig. 3

(Ex. 1005, FIGURE 3)

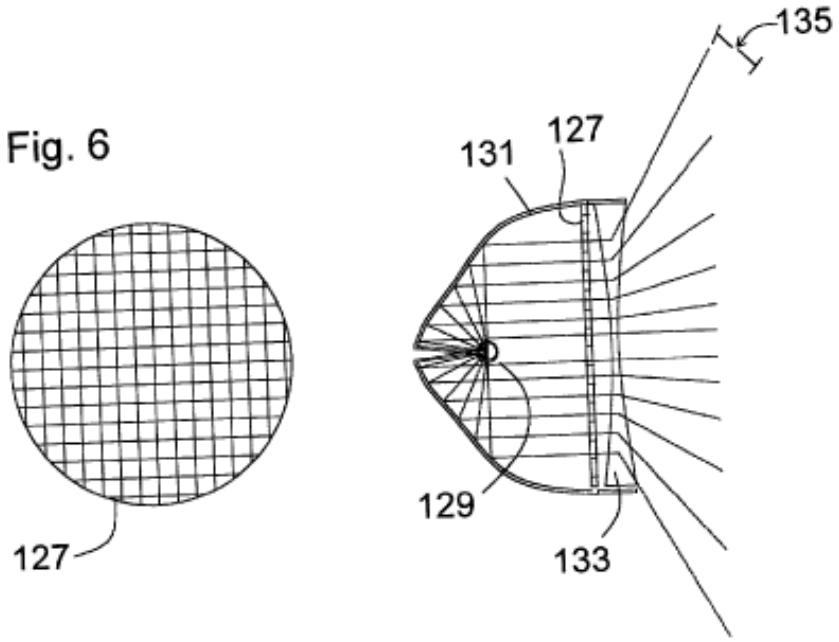
69. In the first of three distinct embodiments, the headlight system sets LEDs of the headlight that have a relationship to one or more distribution area sectors to a predefined low setting. (*Id*., ¶¶[0025-0026], [0029], Figures 1, 2, 5.) Per Figure 5, a headlight 123 employs a single-row array of light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



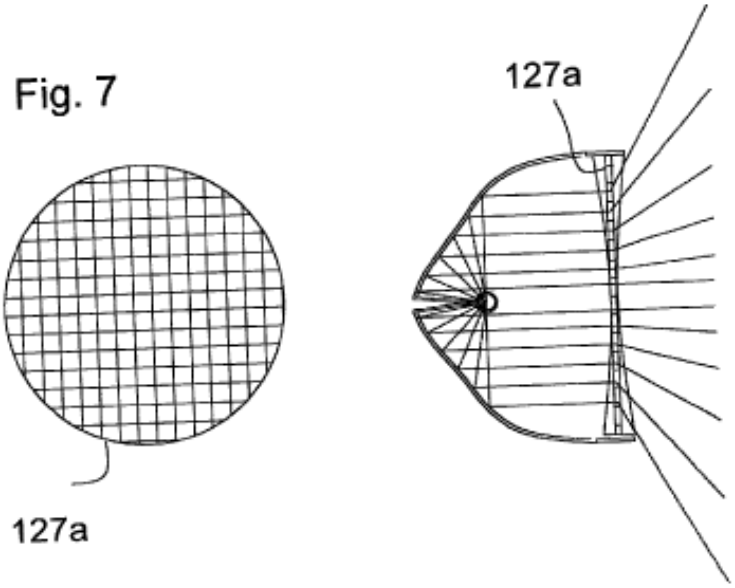
(Ex. 1005, FIGURE 5)

70. The CPU 71 determines sensor (51a, 51b) sectors receiving incoming threshold light, and then bounds a region encompassing the detected light. (*Id*., ¶¶[0026-0029].) The bounding box for each sensor is sent to a corresponding control switch array and switches encompassed by the bounding box limit power to headlamp elements (LEDs, in Figure 5) corresponding thereto. (*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 electro-chromatic elements 127a are integrated within the double concave lens. (*Id*., ¶[0031].)



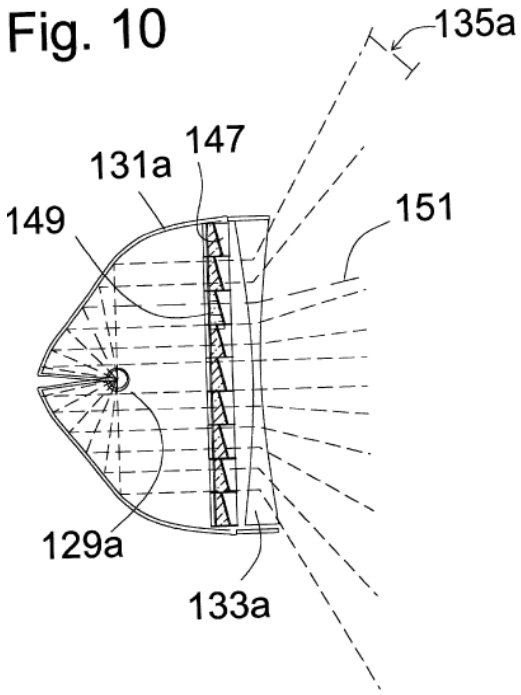
(Ex. 1005, FIGURE 6)



(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 beam portions passing through respective elements. (*Id*.)



(Ex. 1005, FIGURE 10)

73. In this third embodiment, the electro-optical refractive material 147, 149 comprises birefringent 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

[12] Birefringent: "having the quality of birefringence"; Birefringence: "in optics, the power of double refraction." (Ex. 2065, 186).

"bent" in one direction. (Ex. 1005, ¶¶[0050-0052].)

Fig. 8

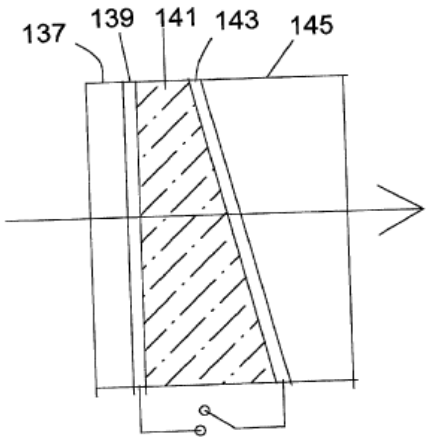
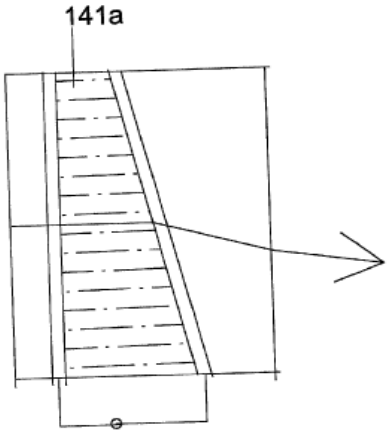


Fig. 9



(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 maximum[.]" (*Id*., ¶¶[0006], [0026].) Alden further states in connection with Figure 3: "… segmented headlight 83 … 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 second headlight system 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. (*Id*., ¶¶[0033-0035], Figs. 8-10.) However, in the first headlight system 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. (*Id*., ¶¶[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 non-collimated light they receive away from the desired sectors of the distribution area. Any headlight resulting from a combination of Alden's incompatible features would therefore be incapable of meeting the basic requirements of a headlight, *i.e*.,

[13] Dr. Papanikolopoulos confirmed that this is one of the objectives of Alden's system in a related IPR proceeding deposition. (Ex. 2041, 50:9-12.)

effectively illuminating the area ahead of the equipped vehicle, let alone directing its emitted light in any meaningful fashion. 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. (*Id*., ¶¶[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

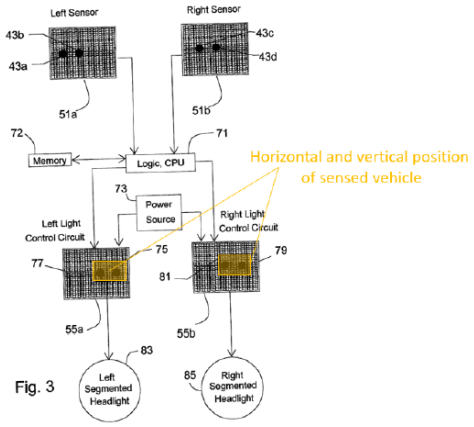
88. Dr. Papanikolopoulos describes each LED as being controlled by a control switch of Figure 3:

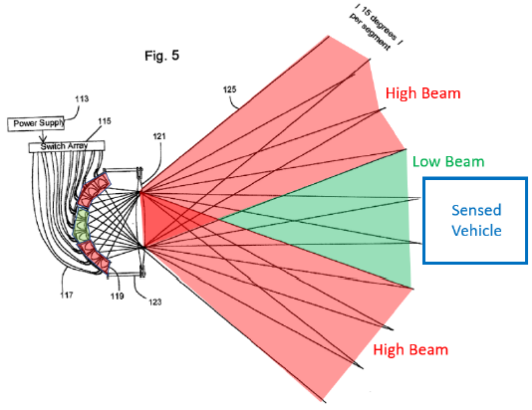
> Q: So what would be the three-dimensional shape of this array that's shown in Figure 5?
>
> A: … it's going to be something that corresponds to… the figure 3 that we have, which is an array matrix of LED elements, each one controlled by each control switch that corresponds to the particular location 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:

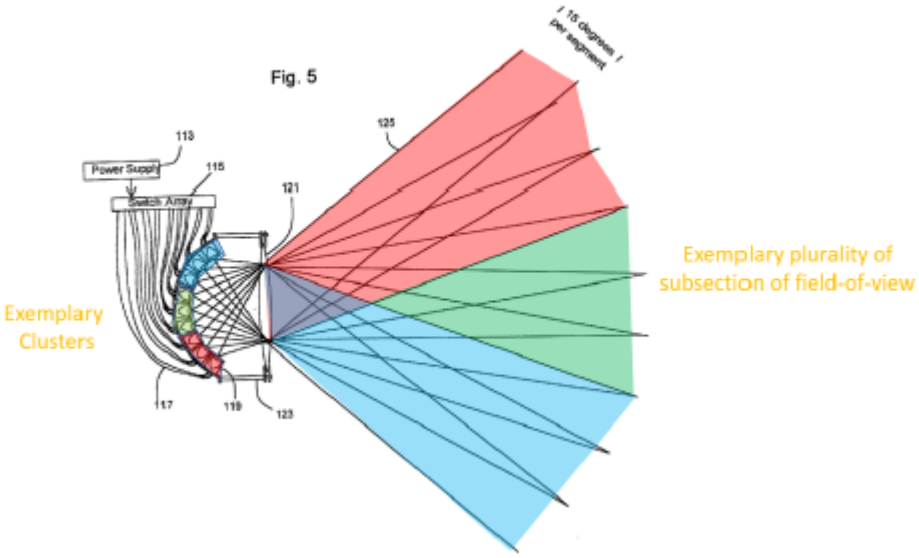
> Q. Okay. So, in your opinion, do the beams overlap?
>
> A. Again, I don't want to speculate on this one because I don't have the exact distance between the LEDs, the placement of LEDs, the angle, the curvature associated with this curve that we see here.

(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.

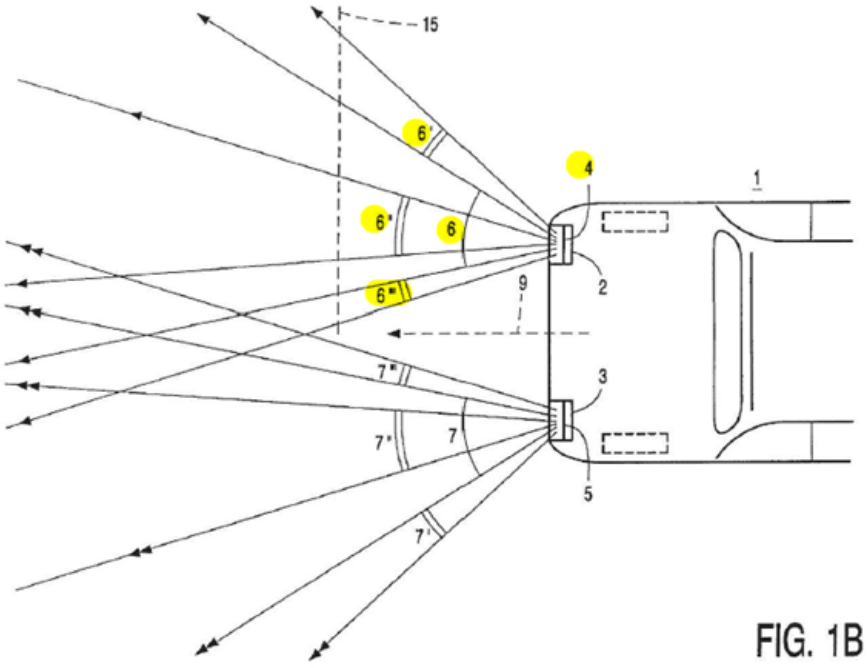
(Ex. 2067, 72:2-75:8.)

101. Intentionally left blank.

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.)



(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.)

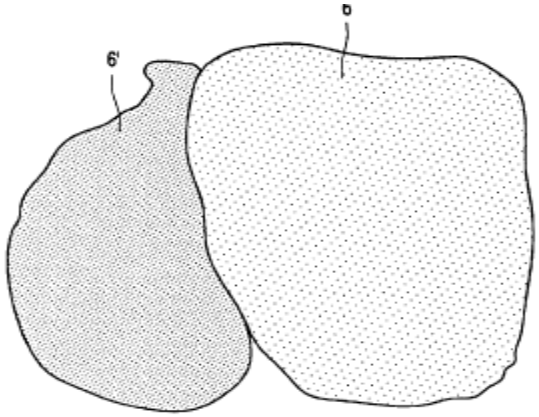


FIG. 3A

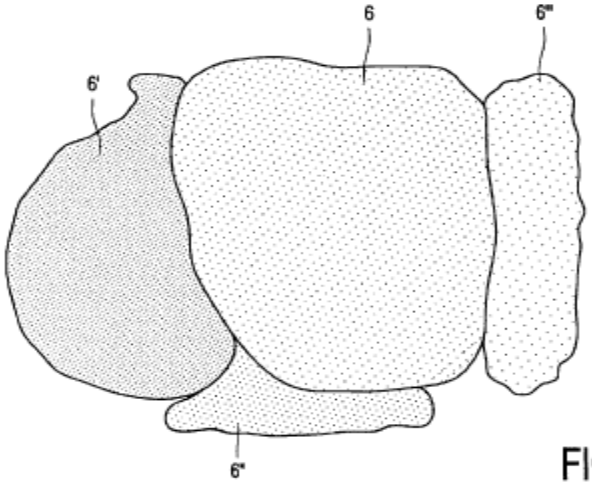


FIG. 3B

(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 light, 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.

D. Beam

113. 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.)

114. 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:

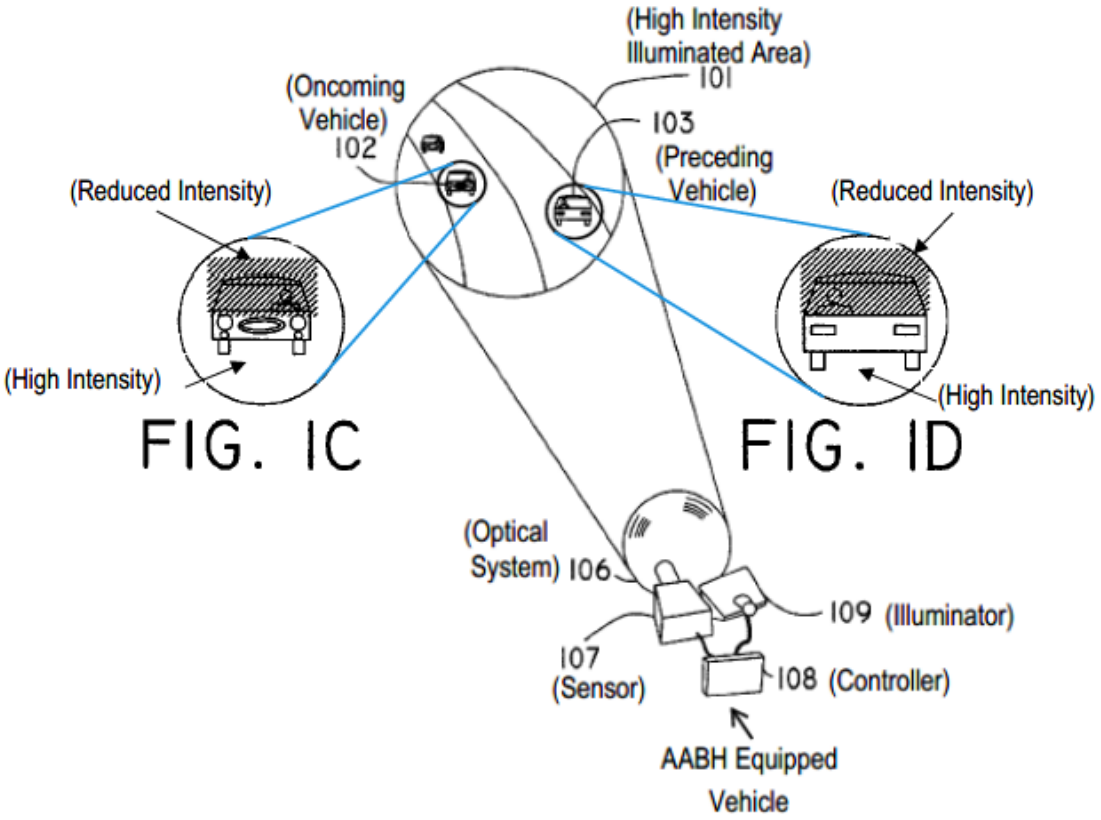
> From the viewpoint of the driver of an automobile equipped with AABH, it will be like having bright high beams on at all times but without concern that the other motorists within the extent of his headlight beam will be dazzled.
>
> * * *
>
> Accordingly, several objects and advantages of this invention 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.)

115. 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.

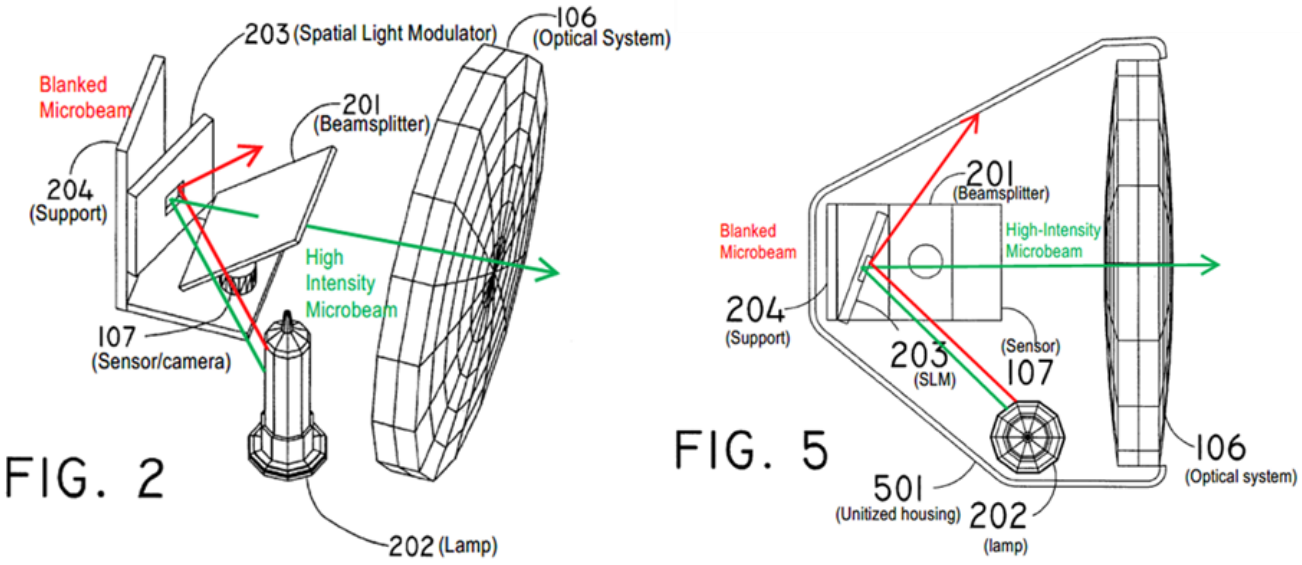
116. Beam provides significantly **reduced** illumination only in those portions of the headlight beam that would otherwise dazzle or annoy other drivers. This is accomplished by "darken[ing] those microbeams that would otherwise illuminate areas near to the source of the impinging beam, thus eliminating the blinding of a driver in an oncoming vehicle, while continuing to provide intense forward illumination." (*Id*., 1:15-19, 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)

117. 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.)

118. 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)

119. 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.

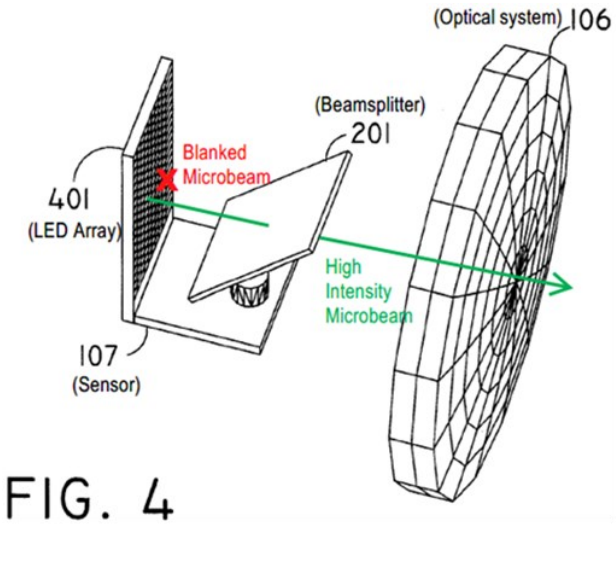


FIG. 4

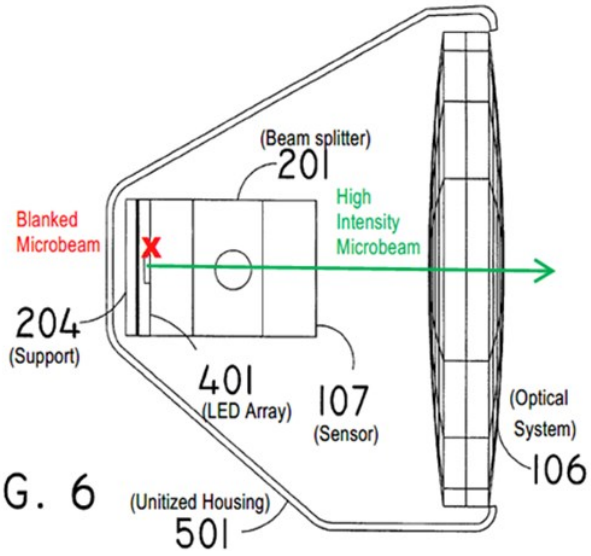


FIG. 6

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

120. 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.)

121. 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.)

122. Intentionally left blank.

123. Intentionally left blank.

E. Kobayashi

124. 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.

125. 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.)

FIG. 6

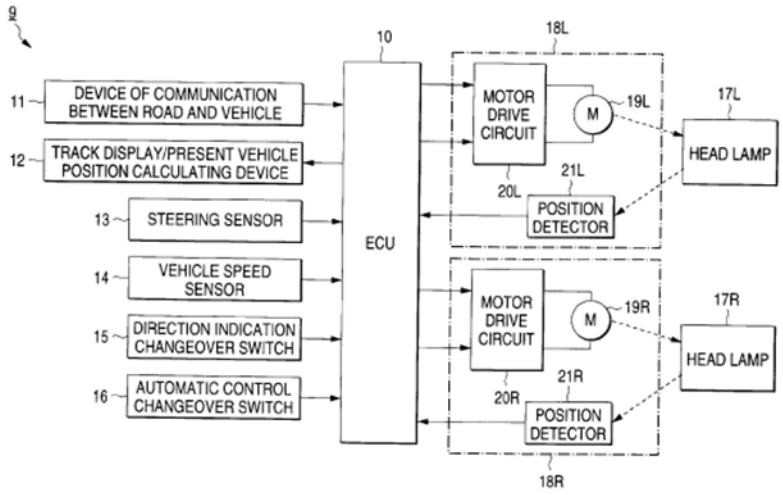
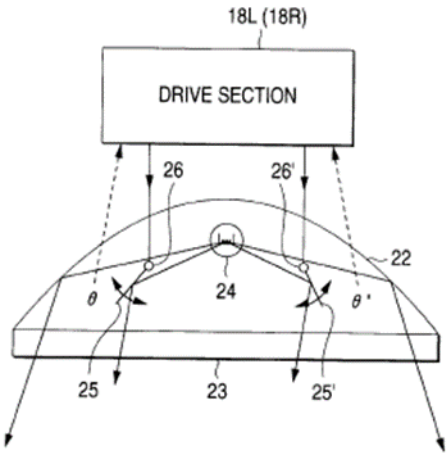


FIG. 7



(Ex. 1006, FIGs. 6, 7)

126. 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.)

127. 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.)

128. 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.)

FIG. 4

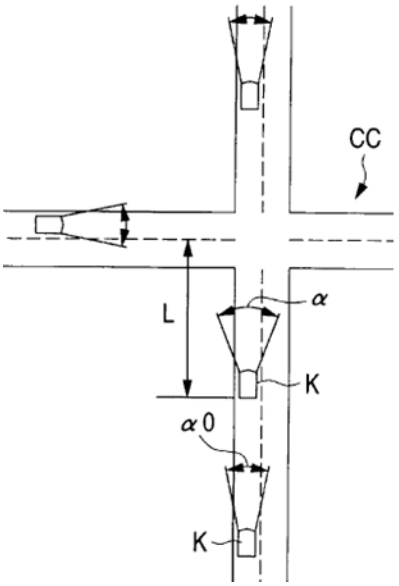
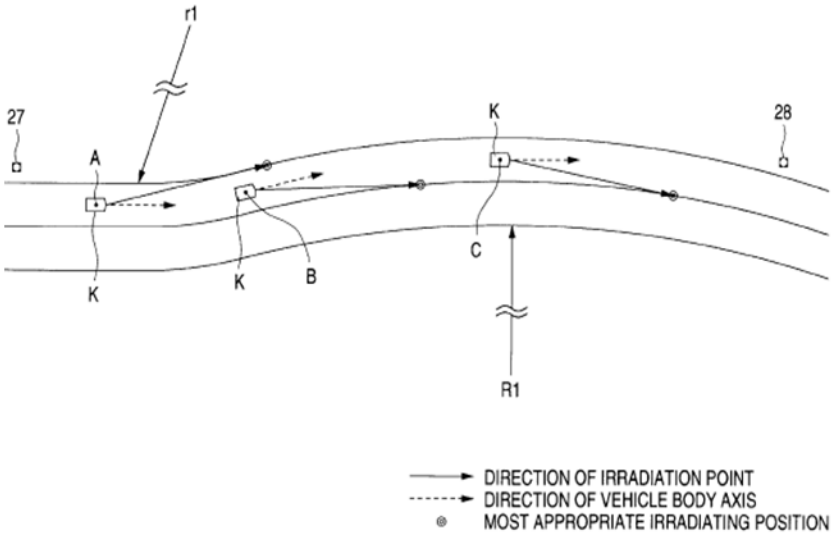


FIG. 10



(Ex. 1006, FIGs. 4, 10)

129. As shown in Figure 4, Kobayashi's headlamp motors are operated to increase horizontal irradiating angle α0 to α>α0 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.)

130. Intentionally left blank.

131. Intentionally left blank.

F. Stam

132. Stam discloses a headlamp having single-function LED arrays with actuation of all LEDs within the array for a particular function, such as low beams or high beams. In the embodiment of Fig. 27, LED headlamp 2700 is controlled to actuate a first LED array in a first lamp section 2703 or a second LED array in a second lamp section 2705. Similarly, in the embodiment of Fig. 28, headlamp 2800 is controlled to actuate a first LED array in a first lamp section 2803 to provide a high beam function, or a second LED array in a second lamp section 2805 to provide a low beam function. (Ex. 1010, 77:30-78:9, 84:21-85:2.)

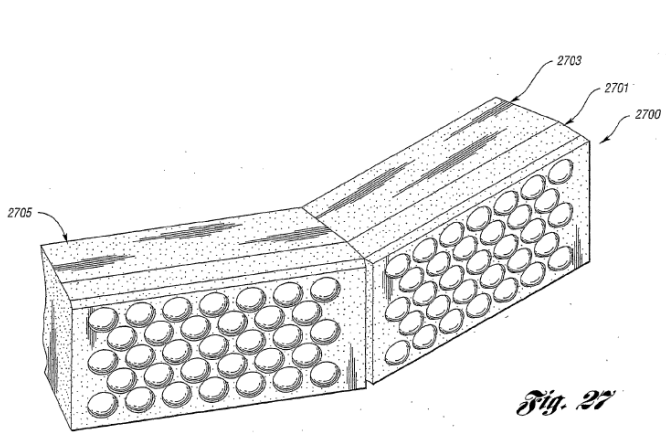


Fig. 27

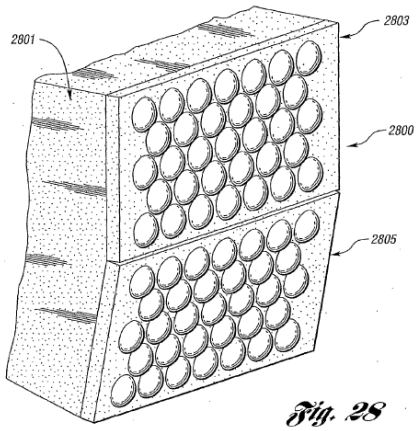


Fig. 28

(Ex. 1007, Figs. 27, 28)

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134. Intentionally left blank.

G. Braun

135. Braun discloses a "Method and Apparatus for Providing Adaptive Illumination." (Ex. 1011, Title.)

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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

138. 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.

139. Petitioner's contentions, 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.)

140. 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].) Alden never mentions any additional rows/columns of LEDs other than the single curved row of LEDs shown in Figure 5, let alone any positioning of such rows. (Ex. 1005, ¶[0029].) Alden's depiction of the row of LEDs being positioned along the focal point of the lens undermines a conclusion that the Figure 5 LED embodiment expressly discloses a two-dimensional array; at a minimum, a POSA would conclude that additional rows, above or below, would still be "positioned along the focal point." 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.)

141. 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 "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, 56:25-57:3; 108:11-109:5; 112:19-113:3.) 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, emphasis added.)

142. 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.)

143. 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, 115:21-116:6.)

144. 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 this 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 that 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.)

145. 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.

146. Intentionally left blank.

147. Intentionally left blank.

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

148. 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, 99:11-16[14].) 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 basically we have here in this demonstrative or illustrative figure." (*Id*., 99:13-100:5.)

149. A similar functional defect arises with how each of the nine LEDs shown in the Figure 5 embodiment are powered by the switch arrays disclosed in

[14] Emphasis added unless indicated otherwise.

Figure 3. Petitioner explains, that "the individual lighting elements … in Figure 5 are '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, 41, citing Ex. 1005, ¶[0029].) 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 array 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. (*Id.*). 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.

150. "The 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.

151. 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.

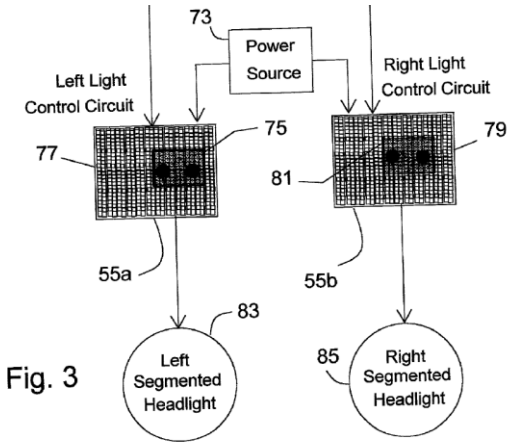
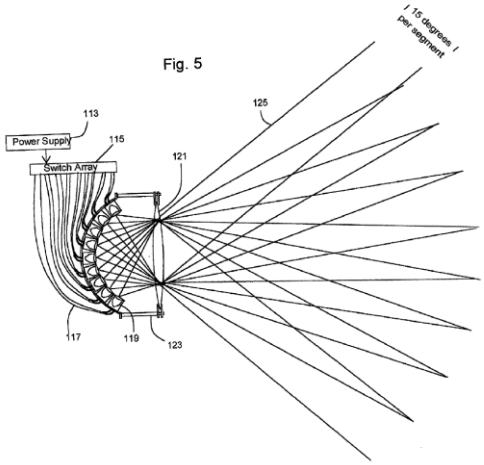


Fig. 3

(Ex. 1005, FIGURE 3)

(Fig 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.)

152. 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.

X. Grounds for Challenge

A. Ground 1: Alden Fails to anticipate at least certain limitations of claims 37-44, 47, 50-56, 58-59, 60-62, 64-65 and 70

1. Independent Claim 37

a. 37[C]: *one or more sensors configured to obtain and provide sensor data, at least a portion of the sensor data indicating a second vehicle within the*

field-of-view;

153. Regarding 37[C], Petitioner states: "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, 17.) Then, per Petitioner, "[t]he logic of Alden's system interprets this data as headlights of an oncoming vehicle, and Alden's CPU selects portions of the segmented headlight system to dim based on this data." (*Id.*, 17-18.) Thus, Petitioner contends that Alden: 1) detects light ("illuminated spots"); and 2) determines that detected light corresponds to the headlights of an oncoming vehicle.

154. Intentionally left blank.

b. 37[E]: ***such that a headlight beam adapted to the pattern substantially illuminates a first subsection of the field-of-view including at least a portion of the second vehicle with an illuminance below a predefined threshold value, while the beam substantially illuminates at least the one or more second subsections of the field-of-view to either side of the first subsection with an illuminance above the predefined threshold value***

(1) Alden alone (anticipation)

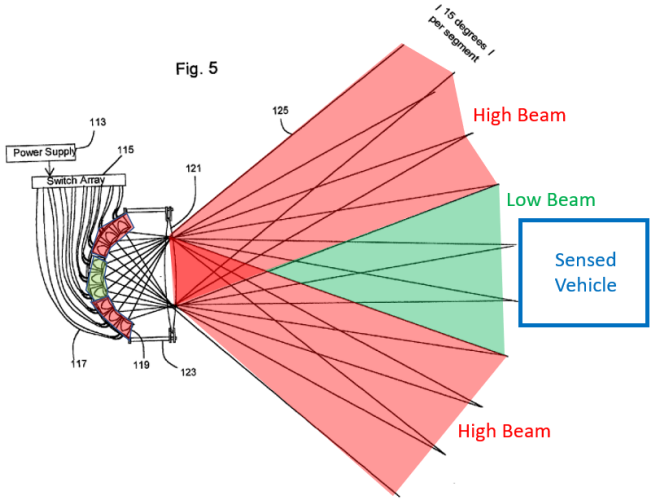
155. For 37[E], Petitioner expressly relies on only two levels of predefined output – i.e., low or high. "[I]ntensit**ies** in between high beam and low beam (e.g., medium) are a 'predefined threshold value' **which the low beam would be below**

and the high beam would be above." (Petition, 24-25.) That is, the full range of intervening intensities possible constitute the "predefined threshold value" with the low serving as the lower threshold boundary and the high as the higher threshold boundary; only low and high are actually **used** for 37[E].

156. Petitioner then states "the low beam's intensity would need to be below a particular threshold – *e.g.*, below a level such that the 'driver of 41 sees only a dim or low beam light from 47.'" (Petition, 25, quoting Ex. 1005, ¶¶[0026]-[0027].) Accordingly, if this is true, then there must be virtually no overlap between beams of Alden, otherwise at certain locations, for example, where beams of "low beam" light overlapped, there would be increased (above low beam) light in those locations, because of the additive nature of light. These overlapping light locations would also be above the level of low beam, and thus definitionally no longer below the proffered "threshold," which was, as noted above, all ranges of illumination between low and high.

157. This is significant because Petitioner relies on Figure 5 to provide illumination "*to either side of the first subsection*," but portions of the beams created by the lamp cross over each other substantially in the colored portions shown. (Petition, 32.) Even if the "first subsection" is the green region, it is unclear where that subsection is *only* illuminated with low beam light, and not additive overlap. The light from each of those three beams shown expands as it travels

further from the vehicle, and so, for example, each of the outer two green beams, of the three green beams shown, may experience at least some additive overlap from both the high beam illumination adjacent to the green triangle, as well as additive overlap from the central beam. If such overlap from adjacent beams existed, it would result in at least portions of those beams that are at an illumination level above low beam. If Petitioner intended to rely on the lines exactly as shown, then there may not be overlap, but of course, then the beams diverge from each other at further distances, which may create other issues. Because Petitioner describes the "threshold" as the "**range** of intensities **between** the high beam and low beam state," any illumination above low beam is not "below" the threshold offered by Petitioner. (Petition, 24-25.)



(Petition, 24 citing Ex. 1005, Fig. 5 (annotated))

158. Given the additive light overlap that may result, it is not possible to conclude, for example, that the region shown for Petitioner's argument is

"substantially illuminated … **below** a … threshold value" over the entire region colored in green. If there is a lesser, more central portion that meets the limitation, then the sections "to either side" of that portion would not be "**above** the … threshold value," they would simply be above the low beam state and within the "range" that Petitioner defined as "the threshold." (Petition, 22, 25.)

159. Petitioner uses Figure 5 without regard to light overlapping, chose two discrete levels of emission for its argument, and chose to define **everything** between those two discrete levels as the "threshold value." Therefore Alden does not disclose "*a headlight beam adapted to the pattern* [that] *substantially illuminates a first subsection of the field-of-view including at least a portion of the second vehicle with an illuminance below a predefined threshold value, while the beam substantially illuminates at least the one or more second subsections of the field-of-view to either side of the first subsection with an illuminance above the predefined threshold value*[.]"

160. Patent Owner asked Dr. Papanikolopoulos in depositions in other proceedings, IPR2023-01039 and IPR2023-01040, about the figure and the beams and did not receive a clear explanation for PO's anticipation argument:

> Q: [B]ack to the figure 5 embodiment. Do these beams overlap? Do each segment overlap?

A: From this diagram – I will only **speculate** from this diagram. (Ex. 2041, 110:20-25, emphasis added.)

***

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 the LEDs, the angle, the curvature associated with the curve that we see here.

***

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 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."

(*Id*., 111:2-8, 112:19-113:4, emphasis added.)

161. Dr. Papanikolopoulos did not clearly explain what the beam pattern looked like beyond what was stated in his declaration.

162. It is unclear from this testimony how Petitioner can rely on Figure 5 as showing anything about how its beams form the illumination claimed in 37[E], when its own expert raises fundamental questions. Because Petitioner has chosen to rely on Figure 5 as shown, and either cannot or will not describe things like

beam overlap, that argument suffers from the noted defects.

163. I also note that Petitioner appears to choose a range of values for the "predefined threshold value," contending "[t]hese intensities in between high beam and low beam (*e.g.*, medium) are a 'predefined threshold value' which the low beam would be below and the high beam would be above." (Petition, 25.) That also fails to map to the claims, which recite a singular "predefined threshold value." (*Id*., 22.)

(2) Alden+Stam

164. Petitioner also attempts to incorporate Stam in its combination, contending that Stam's alleged teaching of 0.1 foot candles (fc) of incident illuminance "would have required nothing more than setting a predetermined illuminance level 'to control the amount of glare experienced[.]'" (Petition, 26.) Stam discusses a few dimming options under specific circumstances that avoid creating illuminance of 0.1 fc incident on vehicles at the respective angles noted in Stam. (Ex. 1010, 1:20-2:5.) Contrary to its assertions, Petitioner's Stam citations fail to support the notion of "setting a predefined *threshold value*," and using that as a benchmark to "set[] the illuminance of low and high beams[.]" (Petition, 26.) Rather, Stam says that "[i]n order to avoid an illuminance of 0.1 foot candles (fc) incident on another vehicle … the vehicle … headlamps should be dimmed" at certain prespecified ranges based on relative positioning of the other vehicle. (Ex.

1010, 1:25-27.) At no point in the cited portions does Stam ever mention "setting" the "0.1 fc" as an illuminance *threshold value* or using a predefined threshold value "in setting the illuminance of low and high beams." (Petition, 26.) At best, Stam appears to be discussing a few parameters of a specific control strategy dictating *when* dimming control should occur to avoid creating incident illuminance of "0.1" fc on another vehicle. Thus, the relied-on Stam disclosure fails to establish the creation of a predefined illuminance threshold value, which is then used to set different illuminance levels for different sections of a field-of-view.

165. Petitioner simply says "[i]t would have been obvious to use such a predefined illuminance threshold value, such as 0.1 foot candles, in the system of Alden. (Nikos Decl., ¶71.)" (*Id*.) Per Petitioner, "[i]ncluding such a threshold level would have required nothing more than setting a predetermined illuminance level to 'control the amount of glare experienced by drivers' as taught by Stam." (Petition, 26, emphasis added.) There is no cited teaching of Stam about "setting a predetermined illuminance level,", so this proposed combination is combining a teaching that simply has not been shown to exist in Stam.

166. Petitioner also says: "[i]n particular, the controllers in Stam would be able to apply appropriate power to the lighting elements for sectors of the headlight distribution area." (Petition, 27.) That appears to be a physical modification

importing a literal controller of Stam, but that combination is not explained. The prior statements were "including such a threshold would have required nothing more than setting a predetermined illuminance level" and "using a predefined threshold as taught by Stam would be an easy, known way." (Petition, 26-27.) None of these statements motivate use or explain use of one of Stam's "controllers." Further, the statement itself does not specifically reference a teaching of Stam about "controllers," so it is unclear what Petitioner even considered to be the "controllers" of Stam, in this context.

167. Petitioner's Alden/Stam combination for the "predefined threshold value" element fails because it fails to rely on an actual teaching of Stam that uses a predefined threshold value in the manner claimed (or use the noted 0.1 fc value in any manner at all), and it fails to motivate any combination of Stam using Stam's controllers.

168. Intentionally left blank.

169. Intentionally left blank.

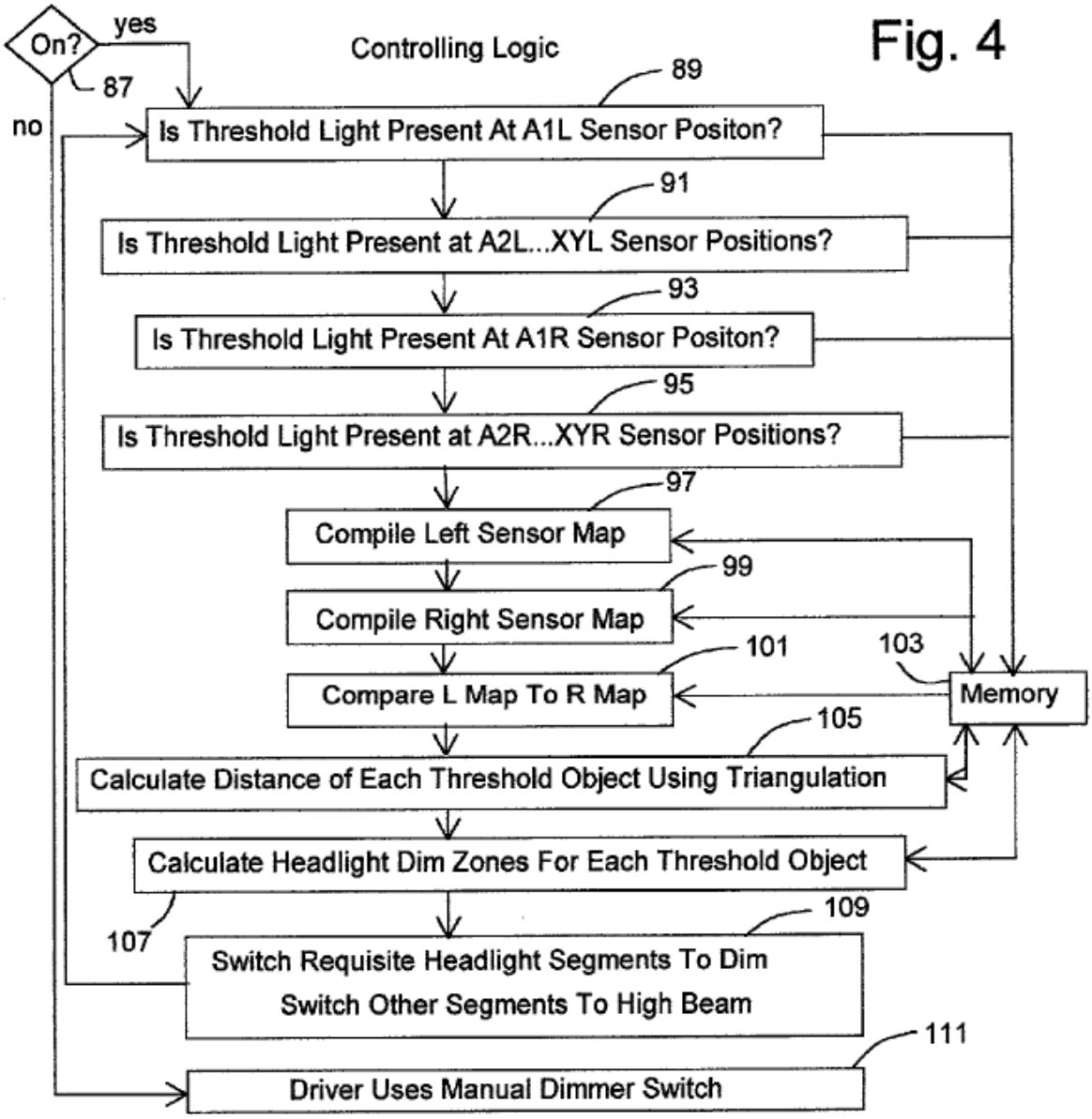
2. Independent Claim 59

a. 59[D]: ***wherein the at least one processor is configured to: determine light output . . . the illumination aimed at the first subsection substantially resulting in light below a first predefined illuminance in the first subsection, and that aims illumination at one or more second subsections of the field of view to either side of***

> ***the first subsection, the illumination aimed at the one or more second subsections substantially resulting in light above the first predefined illuminance in the one or more second subsections*;**

170. This claim requires that the processor is configured to "determine light output for the headlight," among other things. (Petition, 32.) According to Petitioner, "Alden's CPU determines light output for the lighting elements of its system…". (*Id*.) However, this is not a function of Alden's processor.

171. Figure 4 of Alden shows Alden's control logic.



Ex. 1005, Figure 4

172. Once the processor has "calculate[d] [the] dim zones" (Step 107) – i.e., determined the subsections as per Petitioner's argument for limitation 59[C], the only step remaining is to "switch requisite headlight segments to dim/switch other segments to high beam." (Ex. 1005, Fig. 4, ¶[0028].) That is an automatic

step of applying predefined light output and does not involve the processor determining any light output. Nothing in Alden establishes how or where "Alden's CPU **determines light output** for the lighting elements of its system…". (Petition, 32.) The system quite literally just "switches" the determined sector to the single, predefined low value. Moreover, the next step of claim 59 calls for the processor to "*instruct adjustment of one or more of the light sources to achieve the **determined output***" (Petition, 33 59[E]), so to the extent that Petitioner is considering relying on the application of Alden's predefined levels to demonstrate element 59[E], the argument fails, as the *determined output* is something that must have been determined, by the processor, **before** step 59[E]. Because Alden lacks any "determination" of "light output," the argument for claim 59 fails.

173. Further, as with "predefined threshold value," from claim 37, presentation of a "range of intensities" as a "predefined illuminance" does not show anticipation when giving the term its ordinary meaning. Petitioner's proposal to modify Alden with Stam also similarly fails for at least the reasons noted above with respect to the combination.

174. Intentionally left blank.

175. Intentionally left blank.

3. Independent Claim 65

a. 65[B]: *determining illumination for at least a*

> ***first subsection including the second vehicle and at least one or more second subsections, to either side of the first subsection, <u>including determining an illumination level for the first</u> subsection that substantially illuminates the first subsection <u>below a predefined illuminance, and determining an illumination level for the one or more second subsections</u> that substantially illuminates the one or more second subsections above the predefined illuminance;***

176. Petitioner's analogous arguments fail to address a claim requiring "determining an illumination level," and neither proffer for 37[D]-[E] or 59[D] demonstrate "determining illumination level[s]" for any subsection, so the analogous arguments necessarily fail. (Petition, 35.)

177. While the language of claim 59[D] is similar, as shown for that argument, the Petition fails to explain how light output is "determined" by the processor, instead relying on other aspects of elements 59[C] (determining the subsections) or 59[E] (instructing control). The intervening step of actually "determining output" never occurs.

178. Petitioner's argument for claim 65[B] is exclusively by analogy to arguments regarding claim language that is fundamentally different; Petitioner's argument is unclear and not directed to anything about "determining illumination levels."

179. Intentionally left blank.

(1) Claim 38: The headlight system of Claim 37, *wherein at least one of the at least one processors is further configured to process the sensor data to determine illumination for at least one first subsection of the field-of-view, determined to include at least a portion of the second vehicle, based on the sensor data, and for at least one second subsection determined not to include the second vehicle, based on the sensor data*

(a) *determine illumination for at least one first subsection of the field-of-view… and for at least one second subsection*

180. Petitioner relies on its argument for claims 37[D]-37[E] for this element, which fails for at least the reasons noted for claim 65[B] related to "determining illumination" for any subsection. (Petition, 36.) The Petition also offers an explanation related to resultant emitted illumination, and it explains that such emission is in response to detection of an oncoming vehicle. (*Id*., 36.) None of this explains, however, whether or how the system actually "determines illumination" **for** any subsection – it merely determines the subsection and then applies predetermined illumination to those subsections.

181. Petitioner also states that "Data from [] sensors is used to 'determine the intensity of light that will be produced by the 61 [vehicle] in the corresponding headlight sectors." (Petition, 37.) There is no explanation in Alden as to *how* such data would be used to "determine intensity." Instead, what is shown is that Alden

determines a bounding box and then applies a predefined low-beam illumination to that region.

182. Intentionally left blank.

183. Intentionally left blank.

(b) *at least one second subsection determined not to include the second vehicle*

184. Alden is not capable of determining whether a section "does not" include a vehicle. Because a vehicle can overlap multiple sections and the system of Alden has no way of knowing whether non-emitting portions of that vehicle exist, or where they exist, Alden lacks this second determination. Also, Petitioner relies exclusively on analogy to arguments for 37[D] and 37[E] to prove "*determined not to include the second vehicle*," but those claim elements do not recite this limitation. (Petition, 36.) That leaves Petitioner's argument deficient as there is no mention, in the claim language of 37[D] or 37[E] of a second subsection "*determined not to include a second vehicle*."

185. Intentionally left blank.

186. Intentionally left blank.

(2) Claim 39: The headlight system of Claim 37, *wherein the plurality of light clusters are further capable of illuminating at least two of the sub-sections with different illumination characteristics based on the at least one processor determining specific, different illumination characteristics for each of the at least two sub-sections*

187. The entirety of the claim 39 argument is directed at the fact that Alden "can" illuminate different sectors with different illumination. While the explanation about what Alden "can" do may cover the "*capable of*" language generally, it fails to offer any explanation for the claimed "*specific, different illumination characteristics for each of the at least two sub-sections*" element other than providing an argument-by-analogy to claims 37[B] and 37[D]-37[E]. (Petition, 38.) Because neither claim element 37[B], 37[D] or 37[E] call for *determining specific, different illumination characteristics* for a sector per claim 39, Petitioner's argument-by-analogy fails. (*Id*.)

188. Intentionally left blank.

189. Intentionally left blank.

(3) Claim 40: The headlight system of Claim 37, *wherein the light distribution pattern defines illumination for at least the first and the one or more second sub-sections of the field of view*

190. For claim 40, Petitioner argues that the "'light distribution pattern' is

differing illumination levels **output** from the lighting elements." (Petition, 38-39.) "[**T]hat** pattern[,]" according to Petitioner, "defines the light to be produced in 'the first and one or more second subsections[.]'" (*Id*., 39.) The pattern, per the claims, however, is something determined **before** emission occurs – *see* claim 37: "*process the sensor data to determine a light distribution pattern **for** an adaptive headlight beam*." (*Id*., 18.)

191. Accordingly, any **output** – i.e., "differing illumination levels **output** from the lighting elements" - cannot be the pattern of the claims that is a "*determined*" pattern that precedes such output. The argument therefore fails to map to the language of the claims and thus ultimately fails. Any logical leaps that must occur to get from the "output pattern" to the "*determined pattern*" per claim 37 are never explained by Petitioner.

192. Intentionally left blank.

193. Intentionally left blank.

(4) Claim 41: *wherein the light distribution patterns defines illumination for the first subsection designed to result in an illuminance below the predefined threshold value, and defines illumination for the one or more second subsections designed to result in an illuminance above the predefined threshold value*

194. Petitioner's argument for claim 41 is simply an analogy to claims

37[D] and 37[E]. (Petition, 39.) It does not explain why the different additional language of this claim, such as the pattern "*defining illumination*" is covered by the prior argument, or why the language is not addressed.

195. Intentionally left blank.

(5) Claim 42

(a) 42[B]: *one or more light modifying elements provided in a path of light emitted from at least one of the light sources, further controlling at least one light characteristic of the at least one of the light source*

196. Petitioner's claim 41 argument is either a lens 121 or "refractors". (Petition, 41.) There is however no refractor in figure 5, the figure upon which Petitioner relies for their claim 37 argument, from which this claim depends. (Petition, 41-42.) According to Petitioner, the lens modifies a "characteristic" of the emitted light, wherein the characteristic is direction. (*Id*., 42.)

197. Petitioner additionally contends that the "'variable refractive element' in the form of a liquid crystal" enables light to be redirected, showing an example of Fig. 10 of Alden. (Petition, 42-43.) Petitioner then proposes to add this element to Figure 5. (*Id*., 44.Petitioner fails to explain, however, why such disparate embodiments are interchangeable beyond a citation to boilerplate language about "methods … be[ing] used in combination." (*Id*.) Notably, Figure 10 shows

collimated light entering a bi-refringent refractor. (Ex. 1005, Fig. 10.)

198. The light from Fig. 5 is not collimated, and such light, entering the bi-refringent refractors shown in Figure 10, would simply be scattered as it is not entering at an angle suitable for clean refraction or pass-through. (Ex. 1005, [¶¶ [0029], [0033]-[0035], [0053].) Petitioner never explains or addresses this issue, but merely appears to assume that this would simply work. Thus, the two elements are not combinable as proposed, and so the Petitioner is left with lens 121 for this portion of the claim 42 argument.

(b) **42[C]:** ***wherein control of the light sources and light modifying elements results in a specified emitted light-source light characteristic, where said emitted light-source light characteristic includes at least one of direction, intensity, beam spread, spatial light distribution or spectral light distribution.***

199. Limitation 42[C] requires, among other things, "*control of the … light modifying elements*." (Petition, 44.) The Petition does not show how the lens 121 is controlled in any manner, perhaps because lens 121 is not controllable in any manner. Petitioner states that "control of light elements 119, in conjunction with lens 121, results in emitted light with particular intensity, direction, beam spread, and spatial distribution." (Petition, 45.) That sentence, however, expressly notes

the problem – the "control" is only control of the elements 119, not control of the light modifying elements. The phrase "control of the light sources and light modifying elements results in" correlates "control of the" to both "light sources" and "light modifying elements." Petitioner has not explained the latter.

200. As noted above, Petitioner can only reasonably rely on the lens 121 for its argument for claim 42[B] because of the incompatibility of its alternative combination using refractive elements from Figure 10. Petitioner must thus show that the lens is an element subject to control. Since it did not, the 42[C] argument fails.

201. Intentionally left blank.

202. Intentionally left blank.

(6) Claim 43: The headlight system of Claim 42, *wherein the one or more light modifying elements comprises at least one of reflectors or refractors, and wherein at least one of the at least one processors is configured to instruct control of at least one light modifying element resulting in a change to the light-source light characteristic*

203. Again, for at least the reasons why Petitioner cannot rely on the refractive elements for its argument of 42[B], this argument fails claim 43 as well.

204. Petitioner does not cure the issues noted with respect to 42[B] upon which it relies for the "refractor" argument. (Petition, 45.) Additionally, Petitioner

does not explain, for example, how the processor is going to decide whether to control the LED array or the controllable optic. Both systems require control, and Petitioner does not explain if there is a second, separate control circuit for the optic or what controllable system would be controlled when, in the combination.

205. Intentionally left blank.

206. Intentionally left blank.

(7) Claim 50: ***system of Claim 37, further including a computer vision processing unit configured to use the sensor data to identify entities including at least one of beings, vehicles, roadway, or street signs, and wherein the processor is further configured to determine modification of the headlight beam to change illumination of the identified entity***

207. The light sensors of claim 1 are at best, a very rudimentary "computer vision processing unit" that is incapable of "identifying" a vehicle (or anything else). (Petition, 47.) Per claim construction principles, the ordinary meaning of "identify" is to "show to be a certain person or thing; to fix the identity of." (Ex. 2065, 7.) The notion that Alden can "identify" a vehicle is a misstatement of the reference's teachings. (Petition, 49.) In relevant part, Alden determines an area in which light should be diminished, based on the detection of light within that area. (Ex. 1005, ¶¶ [0025]-[0026].) At no point does Alden provide an algorithm or explanation to "show or fix the identity of" the detected light as a vehicle, as

compared to a myriad of other potential light sources.

208. Intentionally left blank.

(8) Claim 54: ***headlight system of claim 37, wherein at least one of the at least one processors is further configured to determine at least a road curvature, indicated by the sensor data, ahead of the first vehicle and to determine a second illumination pattern defining increased illumination in a direction of the road curvature***

209. Petitioner combines its arguments for claims 54 and 60, but given some variances in language, I analyze the claims separately.

(a) ***processors is further configured to determine at least a road curvature, indicated by the sensor data, ahead of the first vehicle***

210. There are several requirements for this portion of claim 54: a) that the processor 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.

211. Petitioner argues 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, 51.)

212. In his first deposition, however, Dr. Papanikolopoulos expressly

stated that the "reflectors" in Alden would "have the same appearance on the image like the headlights" 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. 2041, 78:16-79:15.)

Dr. Papanikolopoulos further 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. 2041, 79:18-80:11.)

213. 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. 2041, 80:7-8.)

214. Without knowing the difference between vehicles and reflectors, a feature not described by Alden, Alden has no way of determining whether it should dim in response to detected light per the Figure 5 embodiment or perform some curve-accommodation per Figure 11, to form "concentrated" high-beam emission. Alden does not describe Figure 11 or elsewhere regarding any ability to determine whether detected light is a reflector indicative of a curve, which warrants curve-emission, or detected light indicative of a vehicle, which warrants glare reduction.

215. Furthermore, even if it is assumed that Alden can somehow distinguish between detected light in the form of road reflectors versus oncoming vehicle headlights, Petitioner's argument that "this data" (detected light) is used to "adjust the LEDs 'responding headlights 155' … so that they 'direct light into the corner …'" (Petition, 51) is not explained.

216. Since the system distinguishes between the two varied light-sources, and as Dr. Papanikolopoulos has explained, the system handles reflectors "by using the same logic of detecting lights" such that reflectors "appear[] … like … headlights," it would be impossible for Alden, without modification, to even determine the presence of a curve based on detected reflection. (Ex. 2041, 79:11-12, 80:6-8.)

217. The reference to the "rotation sensor" is of no help. (Petition, 51.) Steering data is not indicative of a road curvature "*ahead of*" the vehicle, as required by claim 54.

218. Further, arguments about "pre-steering" into a turn do not solve this, because if slight movements of the wheel caused the system to believe a turn was present, then lane changing (when no turn is present), would constantly elicit false positives. That is, slight changes to steering are not or indicative of an upcoming curve, which is probably why Alden "calculates the new direction of the vehicle" before doing anything (Ex. 1005, ¶[0040].) On this last point, Alden's disclosure is

not based on calculation of "the new **planned** direction of the vehicle" as Petitioner contends, but rather based on a calculation involving "**the new planned direction** of the vehicle[;]" – Alden lacks any mention of a "planned" direction. (Contrast Petition, 51-52, with Ex. 1005, ¶[0058].)

219. Intentionally left blank.

220. Intentionally left blank.

(b) ***processors configured… to determine a second illumination pattern defining increased illumination in a direction of the road curvature***

221. This claim requires determining an illumination pattern "defining increased illumination in a direction of the road curvature." The argument presented is a near-verbatim recreation of the argument for claim 15 in counterpart Petition IPR2023-01026, and makes no mention of, for example, a pattern. Thus, the argument fails to map the argument to the language of the claims.

222. Alden does not disclose that the emission of Fig. 5 can be increased in the direction of a curve, or that a pattern, eliciting such an increase, could be determined. The lamp already emits high beams everywhere there is not glare reduction and it lacks any optical steering. (Ex. 1005, ¶[0029].)

223. Further, in 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 you're saying that's what is shown in Figure 5?
>
> A: I say such as shown in Figure 5.

(Ex. 2066, 111:18-112:5.)

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

225. While the second question stated that there were "no curves," the first question establishes that LEDs could be positioned "to ensure that the beam created by the headlamp is sufficiently wide to illuminate turns." (Ex. 2066, 111:20-24.) 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." (Ex. 2067, 17:21-25.)

226. 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." Petitioner's argument thus fails for this additional reason.

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(9) Claim 60: ***processors is further configured to determine at least a road curvature, indicated by the sensor data, ahead of the first vehicle and to determine light output that aims illumination in a direction of the road curvature***

229. This claim calls for the processor to determine the curve in the same manner as claim 54, and this argument fails for the same reasons presented with respect to the comparable element of claim 54.

230. Further, the claim calls for "determine[ing] … light output that aims illumination[] in a direction of the road curvature." (Petition, 50.) In addition to being unable to distinguish between road signs and headlights, as noted for claim 54, it is unclear how the output of Fig. 5 would "aim" illumination anywhere.

231. Petitioner's argument contends that sensor data is used by the CPU to "adjust" the LEDs "so that they 'direct light into the corner …'" (Petition, 51.) There is no suitable explanation as to how such adjustment would occur – the LEDs are emitting at high/maximum illumination, and further, they are not controllable in Figure 5 with regards to anything other than intensity. Thus, the argument ascribes a capability to the embodiment of Figure 5 that simply does not exist, and fails for this additional reason.

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(10) Claims 55 / 56: The headlight system of claim [54 / 37], *wherein at least one of the at least one processors is further configured to determine at least a planned upcoming turn, indicated by the sensor data, and to determine a third illumination pattern defining increased illumination illuminating the turn*

234. This claim requires a *"planned*" turn, as well as definition of a third pattern defining increased illumination illuminating the turn. Instead of choosing a different argument for turn vs. curve, since the claim uses different language and clearly requires a different pattern, Petitioner simply reargues curve illumination. (Petition, 52.)

235. Petitioner never explains how there is a third pattern (different from

the second pattern of claim 54, for example) or how the system of Figure 5 can be controlled, pursuant to such a pattern or otherwise, to provide increased illumination illuminating a turn.

236. Turns are different from curves, as they typically involve the possibility of cross-traffic, and would be accommodated differently. 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." Moreover, Petitioner has not provided a reason why turns and curves are the same. Petitioner seems to try to present a turn as something that happens in a curve, but this is not evidence of a "planned turn," nor does this explanation explain why a third, different pattern is required.

237. Finally, Petitioner argues that "[a]s the steering wheel 'rotates 'x' degrees.' the system calculates the new **planned** direction of the vehicle." (Petition, 52.) What Alden actually describes, however, is that the system calculates the new direction of the vehicle (i.e., where it is now heading, not where it is planning to head) and bases the adjustment on that present heading. (Ex. 1005, ¶[0040].) There is no mention of how the array of Figure 5 could be adapted in any manner to accommodate this information.

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(11) Claims 61 / 62: ***The system of claim [60 / 59], wherein at least one of the at least one processors is further configured to determine at least a planned upcoming turn, indicated by the sensor data, and to determine light output that illuminates the turn***

240. Petitioner relies on its argument for claim 60 and/or claims 54-56. (Petition, 53.) Thus, the issues with the failings related to noting differences between turns and curves persist. Moreover, the system still cannot determine a "planned" turn, and so regardless of the variance in language, the rejection fails.

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(12) Claim 70: ***The method of claim 65, wherein the determining illumination further includes determining illumination that increases illumination of an upcoming curve indicated by the data, wherein the determining the control instructions further comprises determining the control instructions for controlling one or more of the directional light sources to achieve illumination around the curve***

243. Here, Petitioner relies on a variety of arguments – referencing 54-56 and 60-62. (*Id*.) Again, variances in language are unaddressed. Claim 70 requires,

among other things: a) determining illumination that increases illumination of the upcoming curve; and b) determining control instructions for controlling directional light sources to achieve illumination around the curve.

244. The argument suffers from all the shortcomings of the referenced portions of the Petition, including, for example, failure to show how the system of Figure 5 can increase illumination, failure to show how the system determines that there is an upcoming curve, and failure to show derivation of control instructions for controlling Figure 5 elements in the manner claimed.

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(13) Claims 58 / 64: The [headlight] system of claim [37 / 59], ***wherein at least one of the one or more headlamps further includes at least one of reflectors, refractors, or lenses usable to alter emitted light from at least one of the light [clusters/sources] as part of the instructed operation***

247. Petitioner references its arguments for claims 42[B]-42[C] for claims 58 and 64. (Petition, 53.) As noted for those claims, there is insufficient explanation of how bi-refractive elements requiring collimated light input could be used with the non-collimated system of Figure 5. (*Id*.)

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B. Grounds II-V: All Obviousness Combinations

C. Ground II – Alden in view of Harbers

1. Claim 45: *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 alterable, at least responsive to instructions from at least one of the at least one processors, by modifying power to the one or more light sources of the plurality of light sources, resulting in a color change to projected light from the at least one light-cluster illuminating at least one sub-section of the field-of-view.*

a. 45[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*

250. Petitioner's 5[a] argument shows neither a single light source that comprises multiple LEDs, nor a single light source that comprises an organic LED. (Petition, 54.) Instead, Petitioner's argument focuses on light clusters, rather than individual *light sources*. (*Id*.)

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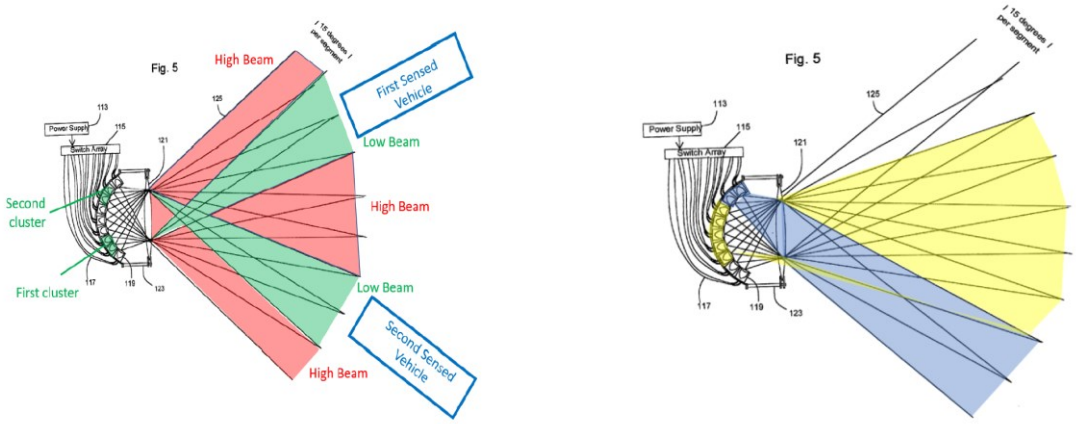
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b. 45[b]: *each light source having a spectral power distribution characteristic alterable, at least responsive to instructions from at least one of the at least one processors, by modifying power to the one or more light sources of the plurality of light sources, resulting in a color change to projected*

light from the at least one light-cluster illuminating at least one sub-section of the field-of-view

253. Petitioner relies on the Harbers' colored LEDs to satisfy this claim limitation. (Petition, 55.) Specifically, Petitioner notes that the LED array may include red, green, blue and yellow LEDs. (*Id.*) What Petitioner has not explained, however, is how including such LEDs into the system of, for example, Fig. 5 will not create color changing issues with emission. Figure 5 of the Alden reference is a nine element LED array that is not otherwise modified by Petitioner for this combination. Thus, each replacement of a colored LED from Harbers into the Alden array, replaces 1/9 of the emission output with a different color.

254. Also, in Alden, each beam segment has defined responsibility for a portion of the field of view—a factor Petitioner's arguments fail to address. Thus, any vehicle, or driver's face, within that area of responsibility, would see the color of light aimed at that portion. As Petitioner has shown, in some of its examples, oncoming vehicles may also be traveling towards the emitting vehicle at angles. (Petition, 29-30.) In such examples, the whole beam of a single, or maybe two LEDs encompasses the oncoming vehicle; thus, the driver of the oncoming vehicle would see red, or yellow, or blue emission beams. In the example shown below (Petitioner's annotated figure from the Petition in IPR01039), the driver's face would be squarely in the "blue" beam.



(Petition, 58, citing Ex. 1005, Figure 5 (Annotated))

255. Moreover, Harbers describes 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, 8:30-31.) Yet, Petitioner has not explained what color effect 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.

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2. Claim 68: *wherein the determining illumination further includes determining a yellowish illumination color for illumination illuminating a road within the field-of-view and a blueish illumination color for illumination illuminating areas off-road within the field-of-view*

258. Claim 68 also requires colored light output for certain regions, this time bluish illumination along a roadside and yellowish illumination in the center

of the road. Again, Petitioner relies on inclusion of "color" LEDs from Harbers. (Petition, 59-60.) But Petitioner never addresses any of the unpredictability selective dimming would have on such a combined Alden-Harbers system, and/or the issues occurring from not following Harber's strict LED ordering to "substantial[ly] reduc[e] … possible color effects." (Ex. 1006, 8:30-34.) Petitioner's proposed combination does not explain how a POSA would address these issues and relatedly, whether these complications would impact a POSA's decision to combine the references.

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3. Claim 69: *wherein the data includes data indicating fog or snow environmental conditions and the determining illumination includes determining a shift of at least a portion of the light output from the headlight system towards yellow*

260. Petitioner relies on usage of colored LEDs from Harbers. (Petition, 60-61). In a one-dimensional array, it is not even clear how such output changing would occur – where each element is singularly responsible for a given segment of the scene. Because Petitioner never expands the array beyond the single row, Patent Owner is left to guess at how many rows would be required to perform any function of Harbers, or how such a configuration would look. Thus, Petitioner does not explain its proposed combination. Also, by relying on colored LEDs, this claim 69 argument suffers from all the deficiencies of the combinations proposed

for claims 45 and 68.

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D. Ground III: Alden in view of Bergkvist

1. Claim 46: *wherein the light output from at least one headlamp further comprises at least one of infrared or ultraviolet wavelengths*

263. For this combination, Petitioner relies on the inclusion of "a UV light source" from Bergkvist. (Petition, 61-62.) Bergkvist uses a single light source that emits in both visible and UV spectrums. (Ex. 1007, 2:63-68.) 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" (Petition, 62) 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.

264. 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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E. Ground IV: Alden in view of Beam

1. Claim 48: *wherein at least one of the sensors is a camera-sensor configured to image at least lights indicative of a preceding vehicle*

267. Claim 48 relates to detecting a preceding vehicle (i.e., taillights). Petitioner argues that if one can detect headlights, one can also detect taillights. (Petition, 63.)

268. Beam however provides no such tuning, it simply relies on detecting light that is indicative of both headlights and taillights. (Ex. 1008, 4:11-16.) Presumably, the modified system would have its threshold tuned downward to include the data of taillights, as they are dimmer than headlights. However, this would 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 illumination "spots" would be bigger. Since Alden does not explain how it pairs lights, the impact on the overall control system is unclear.

269. To further illustrate the issues, a traveling vehicle on a crowded highway would see countless preceding taillights, yet Petitioner's combination provides no explanation of how Alden would "match" such taillights across two

sensors, especially as the taillights would appear much dimmer than headlights. Beam is of no assistance, as it does not attempt sensor-to-sensor matching and Alden never explains such matching for anything more than a single vehicle scenario.

270. As Alden requires that data is matched across two sensors, a great deal of additional modification and/or experimentation would be needed for the proposed combination to accommodate headlights and preceding taillights.

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F. Ground V: Alden in view of Kobayashi

1. Claim 49: *wherein the one or more sensors further includes a GPS sensor*

273. Petitioner relies on Kobayashi's GPS disclosure for satisfying the limitations of claim 49. (Petition, 68.) The combination does not explain 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, 69.) 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. And, Alden lacks any control over its LEDs for curve purposes – they emit, per Alden, at high-beam all the time. Thus, there is no

way to "control" them alternatively to deal with curves. (*Id*.) In light of the preceding issues, a POSA would have no reason to include such a GPS sensor from Kobayashi; Alden's Figure 5 system can do nothing useful with the GPS data. (*Id*.)

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G. Ground VI: Alden in view of Braun

1. Claim 66: *wherein the data includes data indicating a pedestrian and wherein the determining illumination includes determining an illumination level, for at least a third subsection including the pedestrian*

276. For this limitation, Petitioner proposes to replace Alden's lens and photodiode array with Braun's camera and pattern recognition system (Petition, 72-73.) There are several issues with this proposed combination.

277. First, the photodiodes in the array of Alden are mapped to corresponding sensor elements, so it is unclear how that mapping would be converted from Braun's camera to Alden's control circuitry. (Ex. 1005, ¶ [0043].) Petitioner has not shown that Braun uses a similar mapping or similar logic, and so whether or not Braun can image a scene and detect a vehicle, pedestrian or sign, it is unclear how the processor of Braun, now the operational processor of the system, would map to the array of Alden.

278. Second, Braun does not "make assumptions" about where the

oncoming driver is located, and so, losing the processor of Alden, the system loses this capability. A POSA, understanding that decreasing illumination aimed towards headlights is insufficient, would not be motivated to lose the capability to accommodate the oncoming driver. Nor has Braun's processor been modified to account for this aspect of Alden's now-removed processor.

279. Third, the array of Alden is still being used. (Petition, 73.) In addition to the issues with mapping the camera to the sensors, it is unclear how the array of Alden could be used to "spotlight" anything. While the processor of Alden is removed, the "maximum illumination" goal of Alden is not, and so, presumably, the array would be operated at full intensity by the processor of Braun. This issue is not addressed by Petitioner. Additionally, there is nothing to use to "spotlight" pedestrians or signs, since the LEDs are not aimable and further, they are already maximally emitting. If the proposed combination involves *not* applying the maximum emission principles of Alden, which are there for safety, then the combination involves "breaking" the safety goals of Alden in order to create temporary situational safety – something no POSA would be motivated to do.

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2. Claim 67: *wherein the data includes data indicating a road-sign wherein the determining illumination includes determining an illumination level, for at least a*

third subsection including the road-sign.

282. The problems noted for claim 66 apply to the analysis of claim 67 as well, as Petitioner does not bifurcate the analysis between claims 66 and 67. (Petition, 71-74.)

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XI. Conclusion

285. 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.

286. 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