

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Mercedes-Benz USA, LLC,
Petitioner,

v.

Yechezkal Evan Spero.
Patent Owner.

IPR2023-01027
Patent 10,894,503

**SECOND DECLARATION OF DR. NIKOLAOS PAPANIKOLOPOULOS
IN SUPPORT OF MERCEDES' PETITION FOR *INTER PARTES* REVIEW
OF CLAIMS 37-70 OF U.S. PATENT NO. 10,894,503**

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I, Dr. Nikolaos Papanikolopoulos, declare:

I. Introduction

1. I have been retained on behalf of Mercedes-Benz USA, LLC (“Mercedes”) to offer technical opinions relating to U.S. Patent No. 10,894,503 (EX1001) (the “’503 Patent”) and certain prior art references relating to its subject matter in the present case (IPR2023-01027). My qualifications and background are provided in my first Declaration in this IPR. (EX1003.) I submit this Second Declaration to address certain issues raised in Yechezkal Evan Spero’s Patent Owner’s Response (“POR”; Paper 15), Dr. Matthew A. Turk’s declaration (EX2040), and the transcripts of Dr. Turk’s deposition (EX1014, EX1015).

2. I have no financial interest in either party or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

3. In writing this declaration, I have considered the following: the list of materials attached as Appendix A hereto, my own knowledge and expertise, including my work experience in the fields of intelligent vehicle systems, automotive control systems, and lighting control systems.

4. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the ’503 Patent. Unless otherwise

stated, my testimony below refers to the knowledge of one of ordinary skill in the fields as of the priority date of the '503 Patent, or before. For the purposes of this Declaration, I have been asked to assume that the '503 Patent has a priority date of July 12, 2002.

II. Alden's Invalidating Disclosure Requires No Modification and Is Operative

5. I understand that Patent Owner argues Alden's Figure 5 is limited to a single row of LEDs that cannot be reconciled with the two-dimensional sensing and control elements of Figure 3, and that Petitioner's proofs allegedly relying on multiple rows of LEDs thus require modifying Alden. (POR, 17-22.). I disagree. Alden never calls the LEDs a "row" nor indicates that they are "one dimensional." Rather, Alden discloses that "the segmented headlight" as illustrated in Figure 5 is comprised of an "*array*" of lighting elements. (Alden, [0029], Fig. 5.) Figure 5 is simply a sectional view that depicts one row of LEDs in this array.

6. Reading Alden as a whole, a POSITA would readily understand that the segmented headlight as illustrated in Fig. 5 includes multiple rows of LEDs. For example, Figures 6-7 both show (a) a "sectional" view of one row of lighting elements and (b) a "front-on" view depicting the full two-dimensional array of elements within the headlight. (Alden, Figures 6-7.) Similarly, Figure 5 shows a sectional view of a row of LEDs to illustrate the segmented lighting, and a POSITA would understand that the full array in the front-on view (such as similarly shown in

Figures 6-7) would be two-dimensional. Alden also explains that “[a]ll embodiments maximize the areas receiving high beams for the benefit of the equipped vehicle driver while concurrently all areas with other drivers present receive low beams so as to minimize the glare for to betterment of other driver,” which include the embodiment in Figure 5 and the embodiment in Figures 6 and 7. (Alden, Abstract.) Alden also explains that these embodiments could be used “in combination to vary illumination in a segmented system.” (*Id.*, [0061].) Alden even discloses that a switch array similar to 115 as shown in Figure 5 used in the embodiment of Figures 6 and 7. Therefore, a POSITA would have understood that because these embodiments use a similar switch array, share the same objective, and can be combined together, the segmented headlight in Figure 5 similarly has a two-dimensional lighting element array as shown in Figures 6 and 7.

7. Additionally, Alden explains the “array” of LEDs in Figure 5 is controlled by corresponding switches from a switch array using the “CPU and logic previously described” in Figures 3 and 4. (Alden, [0025] (emphasis added); EX1014, 122:12-22.) Thus, a POSITA would understand Alden’s Figure 5 must be read in connection with the descriptions of Figures 3 and 4. Because Figures 3 and 4 disclose the CPU and logic selectively providing high beam and dimmed low beam light in different sectors across a two-dimensional plane, a POSITA would understand Figure 5 to likewise use multiple rows of LEDs. (Alden, Figs. 3-4, [0027]-[0028].)

8. As a further example, Figure 4 discloses the CPU logic compiling two-dimensional (XY) sensor maps of the detected light and determining dimmed and high beam zones *within this XY space*. (Alden, Fig. 4, [0028].) Particularly, Alden discloses the system checks each sector of the left sensor 89, from A1L, A2L through XYL, and similarly checks each sector of the right sensor, from A1R, A2R through XYR. (*Id.*) This is a clear indication that the sensor sectors are distributed in two dimensions, X and Y. For this logic to apply to Figure 5, as Alden expressly says it does, a POSITA would understand that a two-dimensional array of LEDs would be used corresponding to the two-dimensional sensor sectors. In particular, where Alden discloses that the LEDs “are on a curve along the focal point of a headlight lens 121 such that the light from each lighting element goes into a specified portion (or portions) of the headlight distribution area,” Alden is describing directing light into different sectors of a two-dimensional plane in front of the vehicle, which correspond to different sensor sectors. As such, it is again clear that Alden discloses multiple rows of LEDs along the focal point of a curved surface behind the lens to accomplish this. (Alden, [0029].) As I explained at my deposition, the curved surface could be a spherical surface. (EX2041, 119:9-17.) If the LED array were one-dimensional as Patent Owner alleges, then it could only correspond to X locations, and not the plurality of XY locations that Figure 4 and Paragraph [0028] of Alden indicate are accounted for. (Alden, Fig. 4, [0028].)

9. As a final example, Alden discloses additional functionalities its “segmented light distribution elements” can perform, including “directing light to look around corners,” “concentrat[ing] light to look uphill,” and “concentrat[ing] light to look downhill.” (Alden, Figs. 11-13, [0036]-[0038].) In these paragraphs, Alden discloses that it is the “segmented light distribution elements described herein” (which would include those of Figure 5) that can perform these functions, not just the lighting elements of any particular embodiment. (*Id.*) For the segmented headlight of Figure 5 to direct light uphill and downhill, for example, there must be multiple rows of LEDs with some positioned on the curved surface to direct light upwards and others angled and positioned to direct light downwards. And a POSITA would have understood that when the headlight needs to be concentrated to look down, it is likely that the top row of LEDs will be switched on, and when the headlight needs to be concentrated to look up, the bottom row of the LEDs will be switched on. (EX2067, 58:11-59:16.)

10. A POSITA would understand Figure 5 of Alden to illustrate one row of a two-dimensional LED array, with, as Alden explains, each LED used in the array having a corresponding switch in the control switch array. Overall, Alden’s figures are conceptual figures, and not technical schematics intended to represent the precise number of switches and LEDs to be used in a particular real-world system. And, looking at Figures and description, it is clear that Alden is not limiting the sensors

or switches to a particular number of rows or columns, or to a specific total number of sensors or switches. Instead, Alden uses notations like “A1L,” “A2L” and then “... XYZ” sensor positions to indicate there is a first left sensor (A1L), a second left sensor (A2L), and then some “XY” sensor that will depend on the number of sensors actually used. (Alden, Figures 3-4.) Therefore, Figure 3 does not disclose Alden’s system requiring 576 switches, and Figure 5 does not limit Alden’s system to 9 LEDs.

11. I understand Patent Owner further claims Petitioner is “modifying” Alden because I “admitted” that Alden does not expressly describe certain details of its system and read things into Alden at my deposition. (POR, 17-22.) This mischaracterizes my testimony. I have consistently testified that a POSITA would understand Alden’s Figure 5 to illustrate one row of a two-dimensional LED array, with each LED used in the array having a corresponding switch in the control switch array. At deposition, I did not read anything into Alden or suggest that a POSITA would not understand its concepts. Rather, in response to Patent Owner’s questions, I explained how Alden’s figures are conceptual figures (not precise schematics) and gave examples as to what these figures and corresponding descriptions disclose to a POSITA regarding Alden. (See *e.g.*, EX2041, 57:12-58:8, 111:9-23, 115:7-116:14; EX2066, 32:20-34:3, 44:12-22, 47:1-19, 99:21-100:11.)

12. I understand Patent Owner additionally argues that Alden is “inoperative.” (POR 22-24.) Particularly, Patent Owner argues that (1) the LEDs shown in Figure 5 would not provide sufficient lumen output because only a single row is shown and (2) Figures 3 and 5 are incompatible because allegedly “there are 576 switches in the Figure 3 switch array and 9 LEDs in the Figure 5 LED array[.]” (*Id.*) I disagree.

13. These arguments are predicated on Figure 5 being limited to a single row of LEDs. This is incorrect for the reasons explained above. As such, the lumen output of Figure 5 would be greater than that of a single row of nine LEDs, as I explained at my deposition. (EX2066, 99:21-100:5.) Moreover, the claims do not require a particular lumen output or compliance with any standard or regulation—whether for automobiles or otherwise. Indeed, the claims are directed toward a headlight system for a “vehicle,” *generally*, not a headlight system for a specific type of vehicle with a specific required lumen output. (*See, e.g.*, ’503 Patent, Cl. 1; EX1015, 25:7-15.)

14. Further, as explained in my first declaration, it is clear how Alden’s system would work to use a switch array like that in Figure 3 with the LEDs of Figure 5—the switch array should have one switch for each LED. (EX1013, ¶¶54-55, 77; Alden, [0029]; EX1014, 121:3-18.) Figure 3 does not disclose Alden’s system as having 576 switches, and Figure 5 does not limit Alden’s system to 9

LEDs. As I repeatedly emphasized at my deposition, these are conceptual figures in a prior art patent—not technical schematics intended to represent the precise number of switches and LEDs to be used in a particular real-world system. Nothing in Alden contradicts such interpretation. Indeed, Alden discloses that Figure 3 is simply “a more detailed illustration of the information flow, processes and architecture of the elements described in Fig. 2” (Alden, [0027]), and Fig. 5 “illustrates the segmented headlight means and controlling switch array in a first embodiment.” (*Id.*, [0029].) Alden also explicitly states that its description should not be construed as limitations, and “[t]he segmented distribution light can be used for many applications other than motor vehicles.” (*Id.*, [0061].) Indeed, as discussed above, Figure 4 of Alden discloses that there could be some XY number of sensors without limiting the value of X or Y, which clearly indicates that the number of the corresponding switches and lighting elements could be variable depending on the particular implementation. (Alden, Fig. 4, [0028].) A POSITA would have, for example, looked at Figure 3 and the notations in Figure 4, and understood the sensor array, switch array, and the LED arrangement are all two dimensional. No figures in Alden show a headlight that is flat and one dimensional, and instead all figures showing a headlight include a front view or a sectional view of a three-dimensional headlight structure. Thus, the argument of Patent Owner that Figure 5 only contains a single row of LEDs

contradicts Alden’s disclosure and what a POSITA would understand from reading the reference.

15. In sum, when considering the full disclosure of Alden, it is clear that Figure 5 is not limited to a single row of LEDs and that a POSITA would understand the teachings in Alden and how to implement them.

III. Independent Claim 37

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;

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;

16. Regarding Claim 37[E] based on Alden alone, I understand Patent Owner argues that Alden does not disclose an illuminance “below a predefined threshold value” in the first subsection and “above the predefined threshold value” in the second subsection to either side of the first subsection, because Petitioner (1) defines everything between high beam and low beam as the “threshold value” and (2) does not consider light overlapping in Fig. 5. (POR, 28-31.) I disagree.

17. First, as explained in my first declaration, Alden discloses a threshold because Alden teaches the intensity of its low beam light must be dim enough such that it produces “minimum glare.” (EX1003, ¶67.) Stated differently, a POSITA

would have understood from these teachings that Alden contemplated a certain threshold light intensity that the dim, low beam is lower than to ensure it does not cause glare for other drivers, and that the high beam light would similarly be above this threshold to provide “maximum” visibility. (*Id.*)

18. Patent Owner further speculates that even if Alden teaches a predefined threshold, the illumination above and below this threshold by Alden’s system may overlap in some areas. (POR, 29-32.) This is never discussed in Alden and is, in fact, contradicted by Alden’s clear teachings of *separate and distinct beams in specified sectors* that can be either high or low. For example, Alden discloses “produc[ing] 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 [oncoming vehicle] is sensed” with respect to Figure 2. (Alden, [0026]-[0028], Figs. 2, 4.) Thus, the issue of light possibly overlapping at some distance away from the headlight does not change Alden’s express disclosures that certain sectors are set to low beam (below a threshold to avoid glare to another driver), while zones adjacent with no vehicle are set to high beam.

19. Second, with respect to Alden’s disclosure of a range of intensities, not *everything* between high beam and low beam would be considered the threshold value as Patent Owner suggests. (POR, 28.) Instead, the Petition indicated that because Alden says its headlights can operate at a range between high and low, there is some

value within this range, such as “medium” intensity, that the low beam light is set to be below, and that the high beam light is set to be above. (Petition, 25.) That is, the entire range is not a threshold, but rather the “medium” intensity within this range is a singular threshold value, differentiating between low beam and high beam light.

IV. Independent Claim 59

59[D]: wherein the at least one processor is configured to: determine light output for the headlight system that aims illumination at the first subsection, 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;

20. I understand that Patent Owner argues that Alden lacks any “determination” of “light output” as required under Claim 59[D] because its processor automatically applies predefined light output after determining which headlight zones to dim. (POR, 35-37.) I disagree for several reasons.

21. First, there is no “automatic step applying predefined light output” in Alden as Patent Owner contends. (POR, 36-37.) Alden does not simply switch between singular, “predefined” low beam and high beam levels as Patent Owner implies. (*Id.*) Instead, as part of its multi-step process Alden unequivocally says that after its CPU determines sectors where another vehicle is present based on a comparison of left and right sensor map data, and the distance to such vehicle, its CPU uses the “distance information... to *determine the intensity* of light that will be

produced... in the corresponding headlight sectors [where another vehicle has been detected].” (Alden, Fig. 4, [0027]-[0028]; *see also* Petition, 18-24, 28-34.)¹ Again, Figure 4 demonstrates the logic of this process, where Alden determines the illumination for different subsectors. (Alden, Fig. 4, [0027]-[0028].) Then, the processor instructs the adjustment of the LEDs, as information from the processor is “sent to control the power flow from a power source” via the control circuit switch arrays, so that the LEDs produce the desired light output.² (Alden, Fig. 4, [0027], [0028]; *see also* Petition, 18-24, 28-34.)

22. Alden’s process may include determining to illuminate subsections where a vehicle is sensed with dim light and subsections where a vehicle is not sensed with high beam light. (Alden, [0027]-[0028], Figures 3-5.) Moreover, this process happens in real time, such that subsections that were determined to be in dimmed intensity at one time are switched to high beam (for example, when a vehicle is no longer sensed there), and vice versa. (*Id.*; *see also* Petition, 21-22.) Thus, the

¹ Alden’s system is further “operable within a range of intensities between the high beam and the low beam state.” (Alden, [0027], [0061]; *see also* Petition, 22 n. 6.)

² As such, Alden’s system makes the determination of subsections recited in Claim 59[C], determines the light output as recited in Claim 59[D], and instructs adjustment of the LEDs based on the determined output as recited in Claim 59[E].

intensity of light directed to each subsector is not predefined; rather, the system is repeatedly determining the level of light to use based on what it detects and calculates over time, including the distances to detected vehicles.

23. Second, even if Alden’s processor did only determine whether the light output in a first subsection should be a “predefined low value” (which it does not), this is more than sufficient to meet the claim. Claim 59[D] simply requires the processor to determine light output for the first subsection; it does not require the determination be done in any particular way, nor does it require determining a specific numerical intensity.³

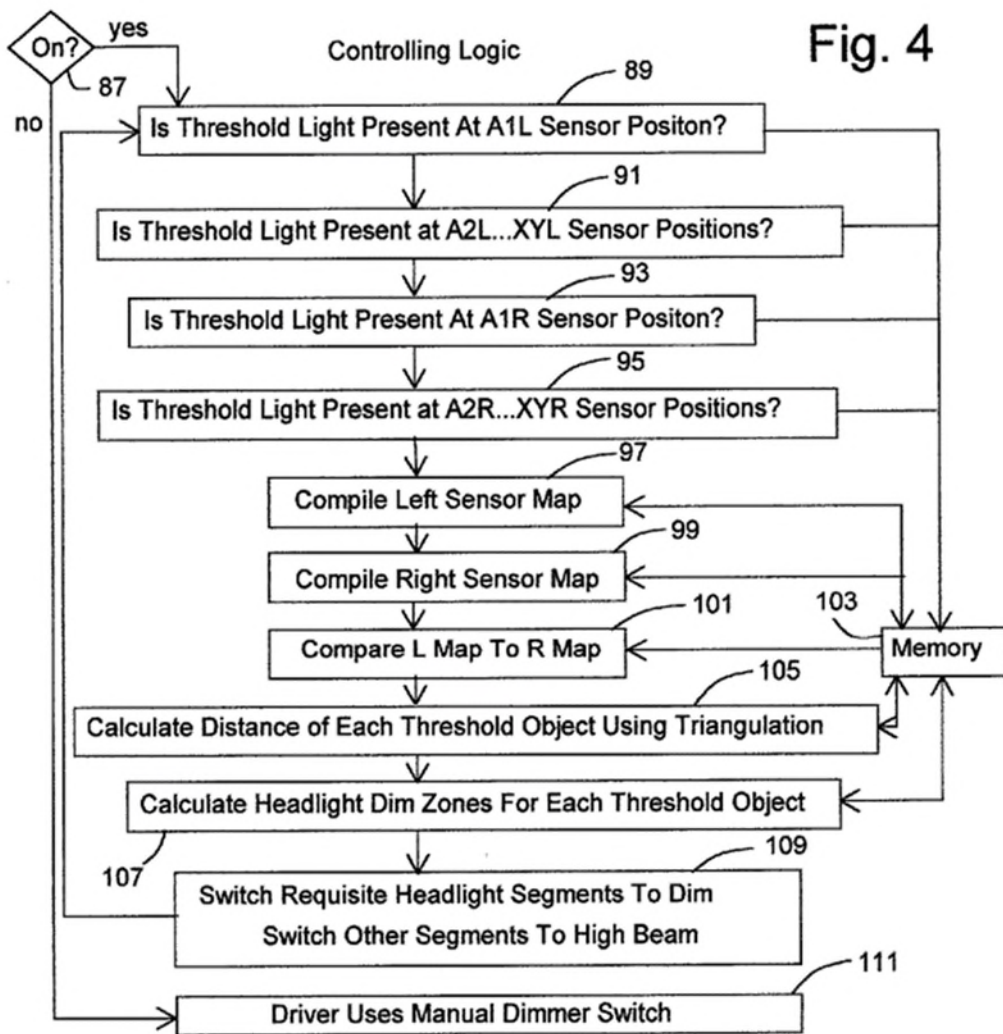
V. Dependent Claim 38

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.

24. First, Patent Owner argues Alden does not “determine illumination” because it uses predefined illumination levels. (POR, 38-39.) This is wrong for the reasons I explained above. *See supra* ¶¶16-23 (Claims 37[D]-[E], 59[D]). Further,

³ I understand Patent Owner argues claim 65 is patentable for the same reasons argued with respect to claims 37 and 59. Accordingly, I disagree for the reasons given above.

in Alden, maps of sensed light are created (e.g., determined) and stored in memory for both the left and right sensor. (Alden, [0028], Fig. 4.) These maps represent areas (e.g., the headlight distribution subsections) in front of the equipped vehicle that are generated from sensor data and may have different illumination requirements. After these maps are compiled, the CPU uses them to determine whether and how the different subsections should be illuminated, e.g., by “compar[ing] the right map to the left map,” “calculat[ing] which zones... need to be dimmed,” and “switch[ing] requisite beam segments to dim” while “switch[ing] other segments to high beam.” These are multiple, independent steps in Alden’s algorithm:



(*Id.*, Fig. 4, [0028].)

25. When comparing the maps, the CPU “determines the distance which [oncoming vehicle] 41 is from [equipped vehicle] 47” (i.e., its location) and that this “distance information is used to determine the intensity of light [e.g., determine the illumination requirements] that will be produced by the [headlight] 61 in the corresponding headlight sectors.” (*Id.*, [0027] (emphasis added).) This determined intensity may be any intensity within the range of intensities from low to high that

Alden discloses its system can operate at. (*Id.*, [0061].) For example, if a vehicle is closer, then multiple sectors may need to be dimmed; a vehicle further away may require only a single sector to be dimmed, i.e., less LEDs need to be dimmed for an oncoming vehicle at further distance. Also, if the oncoming vehicle is at a far distance, the intensity of the corresponding sector may not need to be reduced as much as when the vehicle is closer as the emitted light is already dimmer at a far distance.

26. *Second*, Patent Owner argues that “Alden is not capable of ‘determining’ whether a section ‘does not’ include a vehicle.” (POR, 40-41.) I disagree. Alden is unambiguous that its system provides dimmed intensity where other vehicles are detected and “a second intensity (or alternate direction) of illumination *where no vehicle is detected*.” (Alden, [0025].) Alden is clear how this is done, using a process that detects where sensed light (from headlights of another vehicle) is above a threshold and accounts for the area around the headlights where a driver of the vehicle may be to determine where the other vehicle is present. (*Id.*, [0027][0028].) And, Alden makes a similar determination of where other vehicles are not present – areas where there is not detected light above the threshold and which do not fall within the area around sensed headlights where a driver may be present. (*Id.*) That is, if for a certain location, there was no sensed threshold light and the location is not close enough to an area *with* threshold light such that it could

contain a part of the vehicle (the driver location and placement in a vehicle is considered), then Alden determines this location to have no vehicle present. And, as such, it can be illuminated in high beam.

VI. Dependent Claim 42

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;

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.

27. Regarding Claim 42[B], I understand Patent Owner does not dispute that lens 121 is a “light modifying element.” (POR, 43.) Instead, it argues that Petitioner fails to explain how and why a POSITA would include a liquid crystal variably refractive element in Alden’s system. (POR, 43-46.) I disagree.

28. As explained in my first declaration, Alden describes that a liquid crystal element allows light to pass straight through when a circuit is open, and has a second refractive state causing the light to bend when passing through when the circuit is closed. (Petition, 42-44; EX1003, ¶¶105-107.) Alden further explains that “[o]ne or more methods employed herein may be used in combination to vary illumination in a segmented system.” (Alden, [0061].) A POSITA would have readily understood how to implement liquid crystal variable refractive elements in such a system. (Petition, 44; EX1003, ¶107.)

29. Also as explained in my first declaration, the implementation of a liquid crystal refractor would be the use of a known optical element in a system having different light distribution sectors that Alden describes the liquid crystal as acting upon. (EX1003, ¶107; Petition, 44.) A POSITA would have a reasonable expectation of success as the liquid crystal refractor would perform its same function of allowing light to pass straight through when a circuit is open and bending light when the circuit is closed. (*Id.*)

30. Regarding why a POSITA would implement such a liquid crystal refractor, as I explained in my first declaration, the liquid crystal refractor would provide an additional means of modifying the direction or intensity of individual light sectors, allowing more variable control of lighting subsections of the headlight beam. (*Id.*) For example, as I explained at my deposition, Alden is concerned not only with dimming light when other vehicles are detected, but also illuminating curves in the road. (EX2066, 79:3-83:7.) To achieve this additional control of intensity and direction of light at a curve, Alden's Figure 5 headlight could include a light source with a variable refractive element at either end, so as to be able to bend the light directed towards the sides of the road, and thus any upcoming curves. For example, this variable refractor element could be included with a light source either end of the LED array in the headlight so that it would give the ability to shift light towards the sides of the road if needed, to better illuminate objects there or upcoming

curves. (EX2041, 79:24-80:25.) In optics, a POSITA would have known there are different ways to change direction or intensity of light, and Alden discloses several of these including lenses, electro-optical cells, and liquid crystal variable refractive elements, and mentions the different embodiments can be used together. (Alden, [0029]-[0036], [0061] (“One or more methods employed herein may be used in combination to vary illumination in a segmented system.”).) Thus, a POSITA would have understood from Alden that a light source and variable refractor from Figure 10 could be included at either end of the headlight of Figure 5 in order to give the ability to control and bend light directed to the sides of the road.

31. Regarding Claim 42[C], I understand Patent Owner argues that lens 121 cannot be the “light modifying element” because it is not controllable. (POR, 44-45.) I disagree. The claim language does not specifically require that the light sources and light modifying elements are both controllable as contended by the Patent Owner. Claim 42[A] is clear that the light sources are controlled (via power), but Claim 42[B] recites only light modifying elements being present, but not controlled. That is, Claim 42[C] recites that Claim 42[A] (control of light sources) and 42[B] (inclusion of light modifying elements) “results in a specified light emitted light-source characteristics.”

32. Claim 44, which depends on Claim 42, supports this understanding that the light modifying element does not need to be “controllable,” as it recites that the

light modifying elements include, for example, optical coatings which are simply applied and are not controlled in any way. ('503, Claim 44.) Moreover, Claim 44 specifically recites lenses, *like that in Alden*. Further, in any event, as explained in the Petition and above, controlled light modifying elements such as variable refractors can also be included in Alden's headlight. (Petition, 41-45.)

VII. Dependent Claim 43

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.

33. I understand Patent Owner argues that Petitioner's arguments regarding the variable refractor in Alden being the controlled light modifying element in Claim 43 fail for the same reasons Patent Owner raised for Claim 42[B]. (POR, 45.) However, as explained, a POSITA would have readily understood how to implement liquid crystal variable refractive elements in Alden's Figure 5 headlight and would have been motivated to do so. *See supra* ¶¶24-32 (Claims 38 and 42).

34. I understand Patent Owner further argues that Petitioner does not explain how the control system would work for the combined system. (POR, 45-46.) I disagree. Claim 43 simply requires "at least one of the at least one processors" to "instruct control" of the light modifying element. As I explained in my first declaration, Alden discloses a processor configured to control a control circuit to

change the direction and distribution of light passing through the refractor, which meets the claim requirement. (Petition, 45-46, EX1003, ¶109.) A POSITA would have understood that the control circuit for the variable refractive element can be separate from the control circuit for the LED array, and both can receive instructions from the same processor (or even a different processor).

VIII. Dependent Claims 54, 60 and 70

54 / 60: *The [headlight] system of claim [37 / 59], 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 / light output that aims illumination] in a direction of the road curvature.*

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.*

35. Claims 54 and 60 recite “the 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[.]” I understand Patent Owner argues Petitioner’s contentions fail because Alden allegedly has no way of “knowing the difference between vehicles and reflectors” and, therefore, cannot determine whether its system should dim in response to a detected vehicle or concentrate light in response to an upcoming road curvature. (POR, 47-51, 53-54.) I disagree.

36. As I explained in my first declaration and at my deposition, Alden teaches its system detects different objects by checking for light above a certain “threshold” intensity or distance at each location of the sensor array. (Alden, Fig. 4, [0028]; EX1003, ¶¶60-61, 78, 142.) To distinguish between different objects, such as roadside reflectors or oncoming vehicles, a POSITA would have understood from Alden that the threshold intensity or distance of the process described in Figures 3 and 4 may, for example, simply be adjusted based on the type of object. As I previously explained, the logic of Figure 4 would apply to detecting roadside reflectors, with Paragraph [0036] of Alden now disclosing that instead of dimming where objects (i.e., reflectors) indicating the curve are detected, the system will now “direct light into the corner” by switching LEDs directed towards the reflectors to high beam and switching certain LEDs not directed at the curve to low beam or even off. (EX1003, ¶¶117; EX2066, 114:20-115:14.) Thus, as shown in the Petition, Alden would not simply “dim” all lights directed to the road curve in Figure 11 as Patent Owner alleges, but rather would control the LEDs using the process described in Figure 4 to “switch [] segments to high beam” that direct light into the curve. (Petition 50-51; Alden, Fig. 4, [0028], [0036]; EX1003, ¶117; EX2066, 114:20-115:14.)

37. For Claim 54, I understand Patent Owner additionally argues that Alden’s system does not “increas[e] illumination in a direction of a road curvature”

because it allegedly “emits high beams everywhere there is not glare reduction and [] lacks optical steering.” (POR, 51-53.) Similarly, for Claim 60, I understand Patent Owner argues that it is unclear how Alden’s system can “aim[] illumination in a direction of the road curvature” as the LEDs are emitting at high/maximum illumination. (*Id.*, 53-54.) I disagree.

38. Alden’s system does not default to emitting high beams everywhere there is not glare reduction, as Patent Owner argues. Rather, Alden explains its system can be used for “many applications,” and regarding Figure 11 details an additional functionality of its segmented headlight being “used to concentrate light to look around corners” when the vehicle senses road turns, by directing “light into the corner to maximize the driver’s ability to see there.” (Alden, [0036], [0061]; EX1003, ¶117.) Moreover, Alden explicitly discloses using “the segmented sensing elements and segmented light distribution elements described herein” to achieve maximum visibility when the vehicle approaches the curve. (Alden, [0036].) Further, as shown in Figure 4 at element 109, Alden’s system can “switch requisite headlight segments to dim” and “switch other segments to high beam.” (Alden, Fig. 4, [0027]-[0029], [0036], [0061].) Figures 12 and 13 highlight this as well, showing light distribution patterns that would be output from different LEDs depending on the situation. (Alden, Figs. 12-13.) For example, looking at Figure 12 with light being directed uphill, it is clear that LEDs in the bottom rows would be activated to achieve

the illumination towards the top of the hill. But, when traveling on a straight road, there would be no need to provide illumination that high up. As such, the bottom row of LEDs could be off in such situations (i.e., not defaulted to high beam) and only activated when needed to look up a hill. (*Id.*, Figs. 12-13, [0037]-[0038] (indicating the functionalities of directing light uphill and downhill can be “achieved with the segmented sensing elements and segmented light distribution elements described herein,” which would include Figure 5).)

39. Thus, as a POSITA would have understood, in the context of Figure 11 where the system will “concentrate” and “direct” light into a corner, Alden’s system does not by default have all sectors on high and then dim certain ones. (Alden, [0036], [0061]; EX1003, ¶117.) Instead, it can selectively switch to high beam those LEDs that are positioned on the curve—for example those at one of the extreme ends of the curve in Figure 5—such that they would then direct high beam light into the area of the road curvature to “concentrate” light there. (Alden, [0036], [0061], [0027]-[0029]; EX1003, ¶117.)

40. As I explained in my first declaration, this switching on of LEDs directed at the curve to high beam light is increasing illumination in a direction of the road curvature. (EX1003, ¶117; *see also* Petition, 51.) When the system recognizes a curve, it can perform the additional functionality as described to illuminate the curve while also dimming where needed if other vehicles are present.

Patent Owner’s attempts to confuse the issue by assuming all lights must be on high beam at all times under all circumstances, other than for a detected other vehicle, in Alden are incorrect, and contrary to Alden’s disclosure of the headlights performing multiple functions. (POR, 51-53.)⁴

41. I also understand that, for Claim 70, Patent Owner argues that Petitioner’s arguments fail because it relies on the arguments for Claims 54-56, 60-62. (POR, 56-57.) I disagree for the reasons given above and below, which apply equally to Claim 70.

IX. Dependent Claims 55-56, 61-62

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

⁴ For Claim 54, Patent Owner also argues that Petitioner’s argument is a near-verbatim recitation of the argument for Claim 15 in IPR2023-01026, which does not address “pattern” in Claim 54. (POR, 51.) Patent Owner does not explain what additional requirements the term “pattern” entails, but in any event, Alden discloses determining an illumination pattern that has certain segments illuminated in high beam light that are directed into the corner and can “maximize the driver’s ability to see there,” while other segments of the pattern may be dim or even have no illumination. (Alden, [0029], [0036], Fig. 11.) Such a pattern can be seen, for example, in Figure 11. (*Id.*, Fig. 11.)

turn, indicated by the sensor data, and to determine a third illumination pattern defining increased illumination illuminating the turn.

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.

42. I understand Patent Owner argues that the system cannot determine a “planned” turn. (POR, 55-56.) I disagree. The claims do not specify any particular type of turn or illumination pattern, and Alden discloses creating a third illumination pattern to increase illumination when sensing the vehicle must turn at an upcoming curve.

43. I understand Patent Owner argues curves and turns are different, citing to Dr. Turk, but he simply points to two arbitrarily-selected dictionary definitions of “curve” and “turn.” (POR, 55; EX2040, ¶236.) Patent Owner offers no explanation as to how this relates to Alden or invalidity, and a POSITA would see no reason to limit the terms “curves” and “turns” to these two dictionary definitions. Patent Owner’s arguments regarding these definitions also make no sense. For example, Patent Owner defines turn as a “change of direction when moving,” but I understand its expert admitted a curve also results in a change of direction when moving. (EX1015, 100:4-8.) Similarly, while Patent Owner asserts a curve does have a change in angle required for a turn, I understand its expert also admitted the definition of “turn” makes no mention of any angle. (*Id.*) In any event, even under

these definitions, Alden still discloses the challenged claims—it senses an upcoming curve or turn in the road and controls its headlights accordingly. (Petition, 50-52.)

44. Patent Owner additionally argues Alden cannot determine a “planned” turn, but this is likewise baseless. (POR, 54-56.) Alden’s detection of reflectors along a curve ahead of the vehicle determines a “planned” turn, as the vehicle must turn when it reaches the curve. (Petition, 52, Alden, [0036].) And, as I explained in my first declaration, Alden also discloses a rotation sensor in the steering wheel that can detect when a vehicle is planning to turn, and the system can change direction of the headlight output accordingly. (EX1003, ¶¶119-120; Petition, 52; Alden, [0040].) Patent Owner does not dispute that Alden’s system can calculate the new direction of the vehicle based on data from the rotation sensor. Rather, it argues that the new direction is where the vehicle is now heading, but not where it is planning to head. (POR, 55.) There is no meaningful difference between where the vehicle is heading and where it is planning to head. A POSITA would have understood that the new direction of the vehicle based on the rotation sensor data is the direction where the vehicle is planning to go.

X. Dependent Claim 46

46: *The headlight system of claim 37, wherein the light output from at least one headlamp further comprises at least one of infrared or ultraviolet wavelengths.*

45. I understand Patent Owner does not dispute that Bergkvist discloses the additional elements of Claim 46 (*e.g.*, the headlight beam further comprising UV

light), but instead again argues that a POSITA would not apply this teaching to Alden. (POR, 61-62.) I disagree. First, whether Bergkvist discloses LEDs is irrelevant. What matters is whether it discloses emitting UV light from a headlight, which it does, as I explained in my first declaration. (EX1003, ¶¶135-136; Petition, 62.)

46. Second, Patent Owner alleges the Petition provides no explanation of how Bergkvist's UV light alone (without the filter) could be applied to Alden without also introducing unwanted visible light certain sectors. (POR, 61-62.) But this misconstrues the combination set forth in the Petition—Alden is modified to include the UV light output from Bergkvist “outside the visible range, such that it is not distracting to other drivers or pedestrians but can still illuminate reflective materials such as road signs or markings.” As taught by Bergkvist, the light source would include a filter to remove all the visible light and allow only the UV light outside the visible range to be emitted. A POSITA would have understood to include such a UV light source and filter, or any other UV light source, in Alden so as to be able to emit UV light and better illuminate roadside objects such as signs, road markings, or pedestrians.

XI. Dependent Claim 48

48: The headlight system of claim 37, wherein at least one of the sensors is a camera sensor configured to image at least lights indicative of a preceding vehicle.

47. I understand Patent Owner does not dispute that Beam discloses the additional elements of Claim 48 (*e.g.*, detecting the taillights of a preceding vehicle), but instead again argues that a POSITA would not apply this teaching to Alden. (POR, 62-63.) Patent Owner argues applying Beam to Alden would not work because (1) the threshold used in Alden to detect vehicles would need to be reduced, which in turn would cause Alden to no longer be able to appropriately adjust the light to oncoming vehicles, and (2) Alden would be unable to “match” taillights across its sensors. (*Id.*) I disagree for numerous reasons.

48. First, Patent Owner appears to be ignoring that the teachings of Beam are being applied to Alden, and Beam discloses being able to detect both headlights and taillights. (Petition, 70-72; EX1003, ¶¶137-143.) Patent Owner has not argued or shown that Beam is not enabled. (POR, 62-63.)

49. Second, there is no evidence in the record that the difference in intensities between headlights and taillights is markedly different. Patent Owner cites none. (POR, 62-63.) Thus, there is no reason to assume any significant adjustments would need to be made to Alden when applying Beam’s teachings.

50. Third, even assuming there is an appreciable difference in intensities between headlights and taillights, it is clear from both Alden and the record that a POSITA would be able to take this into account. Patent Owner urges, in essence, that Alden, as modified, would detect and dim light to an overly large area for

oncoming vehicles, without saying why the threshold for both headlights and taillights would need to be the same. (POR, 63.) Instead, Alden as modified by Beam can detect, and separately account for, both oncoming and preceding vehicles. In fact, a POSITA would have readily understood how to account for intensity differences and use two different intensity thresholds, with a lower one being indicative of taillights of a preceding vehicle and a higher one being indicative of headlights of an oncoming vehicle. Additionally, Alden's system also evaluates the location/distance of detected lights in determining the headlight distribution pattern, which could also be used to differentiate between a headlight and a taillight. (Alden, [0028].) Finally, Patent Owner's argument Alden does not explain how it would "match" light detected between sensors fails to understand the art. (POR, 63.) Alden explains that for a given light source, the right and left sensors "will receive spots of nearly identical intensity and size[.]" (Alden, [0027].) Accordingly, Alden could readily match data across the sensors without the need for modification.

XII. Dependent Claims 66-67

66 / 67: *The method of Claim 65, wherein the data includes data indicating a [pedestrian / road-sign] [and] wherein the determining illumination includes determining an illumination level, for at least a third subsection including the [pedestrian / road-sign].*

51. I understand Patent Owner argues that by using Braun's processor instead of Alden's processor, the system will lose the ability to accommodate the oncoming driver. (POR, 65.) I disagree. Alden's system would continue to perform this

functionality. As I explained in my first declaration, Alden's system will be able to detect and illuminate roadway signs and pedestrians by using Braun's detection system. (EX1003, ¶154; Petition, 73.) A POSITA would have understood that Alden's system can use the camera and pattern recognition system of Braun to detect oncoming vehicles and exercise the same control as disclosed in Alden to dim LEDs directed to sectors where the oncoming vehicle is present. Adding the camera and processor functionality from Braun to Alden's system (which already includes a camera and pattern recognition processing) would have been routine to a POSITA as both are based on camera systems used in vehicles that provide information to a processor that controls headlights, and would have provided the system with the additional functionality of selectively illuminating objects such as roadway signs and pedestrians. This would again increase the overall visibility of relevant areas and objects for the driver of the vehicle.

CERTIFICATION

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



Dr. Nikolaos Papanikolopoulos

Dated: July 3, 2024

APPENDIX A

Materials Considered

Exhibit No.	Description
1001	U.S. Patent No. 10,894,503 (“ 503 ”)
1002	Original File History for the ’503 Patent
1003	Declaration of Dr. Nikolaos Papanikolopoulos
1004	Curriculum Vitae of Dr. Nikolaos Papanikolopoulos
1005	U.S. Patent Publication No. 2003/0,137,849 (“ Alden ”)
1006	WIPO Patent Publication No. 2001/001038 (“ Harbers ”)
1007	U.S. Patent No. 4,970,628 (“ Bergkvist ”)
1008	U.S. Patent No. 6,144,158 (“ Beam ”)
1009	U.S. Patent No. 6,049,749 (“ Kobayashi ”)
1010	WIPO Patent Publication No. 2001/070538 (“ Stam ”)
1011	WIPO Patent Publication No. 2002/004247 (“ Braun ”)
1012	PTAB Trial Statistics April 2023 IPR, PGR
1013	Second Declaration of Dr. Nikolaos Papanikolopoulos
1014	First Deposition Transcript of Dr. Mathew A. Turk
1015	Second Deposition Transcript of Dr. Mathew A. Turk
Paper 15	Patent Owner’s Response
2001	Declaration of Mathew A. Turk
2040	Second Declaration of Mathew A. Turk

2041	Deposition Transcript of Dr. Nikolaos Papanikolopoulos
2066	Second Deposition Transcript of Dr. Nikolaos Papanikolopoulos
2067	Third Deposition Transcript of Dr. Nikolaos Papanikolopoulos