

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MOBILEYE GLOBAL, INC.,

Petitioner,

v.

MANDLI COMMUNICATIONS, INC.,

Patent Owner.

Case IPR2024-01110

Patent No. 9,335,255

**EXPERT DECLARATION OF CHARLES E. THORPE IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW**

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I. INTRODUCTION AND SUMMARY OF OPINIONS

1. I, Charles E. Thorpe, have been retained as an independent expert by Mobileye Global, Inc. (“Petitioner” or “Mobileye”) in connection with an *inter partes* review of U.S. Patent No. 9,335,255 (the “’255 patent”) (Ex. 1001). I have prepared this declaration in connection with Petitioner’s Petition for *Inter Partes* Review. I believe the statements contained in this declaration to be true and correct to the best of my knowledge.

2. I have been asked by Petitioner to provide my opinion on the technology claimed in claims 12-15 and 17-23 of the ’255 patent (the “Challenged Claims”) and whether the Challenged Claims would have been obvious to a person of ordinary skill in the art (“POSITA”) at the time of the earliest claimed priority date of the ’255 patent, which I have been asked to assume is August 12, 2000. This declaration sets forth the opinions I have formed, the conclusions I have reached, and the bases for these opinions and conclusions. Based on my experience, and knowledge of the art at the time of the earliest claimed priority date, it is my opinion that claims 12-15 and 17-23 of the ’255 patent would have been obvious based on the asserted grounds discussed below. A POSITA would have found it obvious to combine the prior art references I cite and would have been motivated to do so before the priority date. I was not asked to provide any opinions that are not expressed herein.

II. BACKGROUND AND QUALIFICATIONS

3. I believe that I am well qualified to serve as a technical expert in this matter based upon my educational background, career history, publications, and other relevant qualifications, which I summarize below. I understand that my curriculum vitae, which includes a more detailed summary of my background, experience, patents, and publications, is attached as Exhibit 1004.

4. I have been working with vision-guided vehicles for over 40 years.

5. My undergraduate degree is in Natural Science from North Park College, now University, in Chicago IL. I then received a Ph.D. in Computer Science from Carnegie Mellon University, where I studied artificial intelligence under Professor Herb Simon, who had recently received the Nobel Prize for his work on artificial intelligence, and under Professor Allen Newell, both of whom are widely credited for being two of the founding fathers of artificial intelligence. My thesis committee included my advisor Professor Raj Reddy, founder of The Robotics Institute, a member of the National Academy of Engineering, a Turing Award winner, and past co-chair of the President's Information Technology Advisory Committee, and Professor Takeo Kanade, arguably the most-decorated roboticist, member of the National Academies, and recipient of numerous awards for his contributions to robotics and computer vision.

6. My Ph.D. thesis project, titled *Vision and Navigation for a Mobile Robot*, built a binocular vision system for a robot. By finding the same object in the left image and right image, and using triangulation, the robot determined the distance to those objects—a simple form of depth perception. By tracking those objects as the robot moved, it was able to update its own estimate of its motion—an early form of SLAM, or Simultaneous Localization and Mapping. The robot succeeded in crossing our lab under autonomous vision control and was used for simple outdoor demonstrations. This work was sponsored by the Office of Naval Research.

7. As I was finishing my Ph.D. thesis, the Advanced Research Projects Agency of the Department of Defense (“ARPA,” since renamed “DARPA”) was becoming interested in using the supercomputers it was developing to solve problems of interest to the military. The Strategic Computing initiative had an effort for the Air Force (Pilot’s Associate, including speech understanding for a pilot to communicate with an intelligent assistant) and an effort for the Navy (involving task force scheduling). For the Army, the application selected was an autonomous scout, called the Autonomous Land Vehicle. I helped write two proposals that were funded: Road Following, involving perception for unmanned vehicles to travel on roads; and a systems integration project that built software to allow vision systems to talk to planners, to talk to controllers, and to manage all the

details of real-time planning and travel. My team had our own testbed vehicle, called Navlab I (for Navigation Laboratory).

8. I was a co-investigator and then lead investigator of the Navlab group. The Navlab group built several systems for road following: one based on color classification for finding and following paved paths that may not have lane markings; one based on finding painted markings, potentially of different colors and running at different angles; and a neural network that automatically learned what the most salient features were and used them to steer the vehicle. We received one of the first scanning laser rangefinders. This used a laser to measure distance to objects and a pair of mirrors to scan the beam left and right and up and down so a complete depth image was obtained every $\frac{1}{2}$ second. We used the laser rangefinder to detect obstacles and to find landmarks and update our position. The rangefinder also had a channel where it measured the amount of light reflected back from the points being scanned. We trained the neural net to use the reflectance image to autonomously steer the vehicle. We built maps, planning systems, and control mechanisms. A video showing some of the components in Navlab I as of 1990 is Navlab 90 Neighborhood Navigation, found at <https://www.youtube.com/watch?v=0GXuqw3cgwU>. An edited collection of papers produced by the Navlab group is in the book Vision and Navigation: the Carnegie Mellon Navlab, published by Kluwer Academic Publishers, 1990.

9. The DARPA work with the Autonomous Land Vehicle, funded from the mid 1980s to 1999, led to two different directions for successor projects. The military side transferred directly to the Army Research Labs, with their Demo II and Demo III projects. We built two automated High Mobility Multipurpose Wheeled Vehicles (“HMMWVs,” also commonly known as Humvees), so we could continue our on-road work and do more off-road driving.

10. The Department of Transportation also became interested in our work. The National Highway Transportation Safety Administration had an Office of Crash Avoidance Research, with the charter to reduce road collisions. They had separate efforts to address rear-end collisions, lane-change collisions, and collisions at intersections. In the 1990s, we won the contract to work on Run Off Road Collision Countermeasures. Crashes where the vehicle departs the roadway are not as common as the other types but are much more likely to cause a fatality—hitting a tree is a larger impact than side-swiping an adjacent car. The vast majority of those collisions are caused by driver error, ranging from simple inattention to poor judgment to driving too fast for the visibility conditions. We approached the problem from a number of angles: how do these collisions actually occur; how long in advance would you have to warn a driver in order to avoid a crash; and, of course, how do you build a computer vision system that sees what the road is doing ahead so you can generate an appropriate intervention.

11. At the same time that NHTSA was working on collision avoidance, Federal Highways was starting a much larger project: fully automated driving. Our Navlab group at CMU Robotics was a part of the winning consortium for the National Automated Highways System Consortium (“NAHSC”). General Motors was the lead; Bechtel and Parsons-Brinkerhoff worked on roadways; Delco and Lockheed Martin (including some of our old colleagues from the Autonomous Land Vehicle and Army Demo II projects) did systems engineering; CALTRANS provided roadways and an operator’s insight. Berkeley, through the California PATH consortium, and our Navlab group were the autonomous vehicle providers. The Berkeley system relied on magnets buried in the pavement and low-latency communications among cooperative cars to show how tightly packed the autonomous systems could be. Our approach, in contrast, emphasized intelligent vehicles surrounded by sensors, so the autonomous system could be mixed in with other human-controlled vehicles. We had video cameras, radars looking forward, sideways, and rearwards; we experimented with sonars and built our own phased array radar; we used infrared cameras and high-accuracy GPS units.

12. The culmination of the NAHSC project was a showcase on the HOV lanes of I-15 in San Diego in 1997. We built two computer-controlled Pontiac sedans, a computer-controlled Oldsmobile minivan, and two full-sized city buses: Navlabs 6 through 10. The 1997 Automated Highway Demo was a success. We

carried over 1000 passengers, including the U.S. Secretary of Transportation, all under automated control.

13. In 2000, I became Director of The Robotics Institute at Carnegie Mellon. As Director, I had an overview of all of the work going on across more than 40 active faculty. During my whole time at The Robotics Institute, my work concentrated on perception for wheeled vehicles but also included work for underwater autonomous systems, flying robots, and walking robots for planetary exploration.

14. In 2004, I was asked to become the founding Dean of Carnegie Mellon's branch campus in Qatar. I along with two of my PhD students that came with me continued active research from Qatar. We received one of the inaugural grants from the Qatar National Research Fund and were the first to complete a project and submit our final report.

15. When I returned from Qatar, I worked in the Office of Science and Technology Policy, Executive Office of the President from 2011-2012. My immediate boss, Aneesh Chopra, was the Chief Technology Officer of the United States. The head of OSTP was Dr. John Holdren, the President's Science Advisor. My title was Assistant Director for Advanced Manufacturing and Robotics. In the Advanced Manufacturing side, four of us served as the staff to help the President's Committee on Advanced Manufacturing set up the Advanced Manufacturing

Institutes. On the Robotics side, one of my activities was hosting a workshop on the difficulties of robotics response to the Fukushima nuclear reactor disaster. As a result of that workshop, DARPA initiated the Robotics Challenge, creating robots that can cross rubble fields, climb stairs, open doors, and do a series of activities that simulate a response to a nuclear disaster.

16. I came to Clarkson University in 2012. I served a full 5-year term as Provost. When I finished that term and stepped down, I was asked to serve as Dean of Arts & Sciences until a new Provost arrived and selected her own Dean. I have been back in the classroom since then. My research includes projects on unmanned aerial vehicles and on teleoperation of ground vehicles with multiple sensors. I continue to serve on Ph.D. thesis committees dealing with perception systems.

17. Throughout, my research has been well received. I am a Fellow of the Association for the Advancement of Artificial Intelligence, and a Fellow of the Institute of Electrical and Electronic Engineers. My awards include:

- IEEE Intelligent Transportation Society “Institution Lead Award” to the Navlab group, 2009.
- C. Wang, C. Thorpe and S. Thrun. Best Paper Award for “Online Simultaneous Localization and Mapping with Detection and Tracking of Moving Objects: Theory and Results from a Ground Vehicle in Crowded

Urban Areas” in *Proceedings of the IEEE International Conference on Robotics and Automation*, May, 2003.

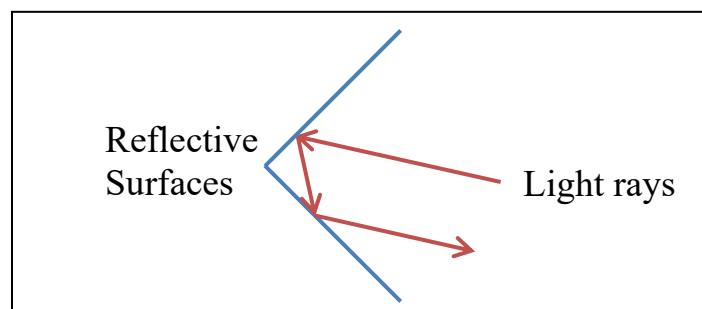
- Vectors of Pittsburgh, “Man of the Year” Technology Award, 2002.
- ROMAN 2001 Best Paper Award for “Multi-robot Driving with Collaborative Control.”
- Pennsylvania Quality Initiative Award, 1999, to the CMU Navlab group, for the 1998 Advanced Safety Bus Demonstration
- The National Automated Highway Systems Consortium, of which I was a part, received three awards at the 1998 ITS America Annual Meeting: Outstanding Achievement in Research, Development and Innovation; Outstanding Achievement in Intelligent Vehicles; and Most Effective ITS Promotion by a Public-Private Partnership.
- Newell Award for Research Excellence, 1997.
- Best Paper award. Single Leg Walking with Integrated Perception, Planning, and Control. E. Krotkov, R. Simmons and C. Thorpe. In Proceedings of IROS 90.

18. I have served on many advisory committees. For 12 years, I was on the Scientific Advisory Committee for CO-ME, the Swiss national research consortium on medical robotics. I was a member of the DARPA Defense Science Research Council. I chaired the IEEE-USA Research and Development Policy

Committee. Most significantly, I have served on 7 committees for the National Academies. In the most recent of those (2023-24), I chaired the review of Military Information Systems for Army research, both in-house and extramural, as part of the Technical Advisory Board for the Army Research labs.

III. BACKGROUND OF THE TECHNOLOGY

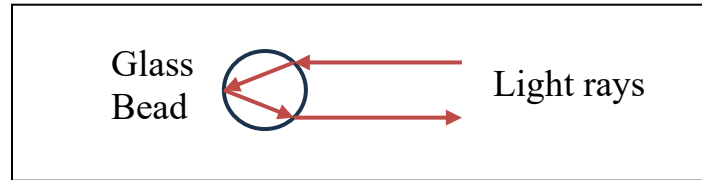
19. Making sure that road signs and other road markers are visible has long been an important factor in their design and maintenance. As road signs wear, they become harder to see, particularly at night, and need to be replaced. One key to making road signs visible at night is retroreflectivity. The sign material is designed so that a large fraction of the light from headlights is reflected back in the direction of the driver, making the signs brighter and easier to read. One common way this is accomplished is by “corner cube” shapes (sometimes called cube-corner shapes) embedded in the sign. In a 2-D drawing, if two reflective surfaces are placed at a 90 degree angle, any ray of light hitting one surface will bounce off of that surface, then the second surface, and will return on a parallel path towards the light source. This concept is depicted in the diagram below.



20. In three dimensions, the same end result can be accomplished by adding a third reflective surface perpendicular to the first two—the surface looks like the inside corner of a box, hence the name “corner cube.” The sign material can have many of these tiny corner cubes covering the entire area of the sign. Note that small imperfections in the returned angle are good: if the corner cubes were perfectly retroreflective, all the light from a headlight would be reflected back to the headlight, and not to the eyes of the driver. This kind of material is well-known and is described in several references published long before the priority date of the ’255 patent. *E.g.*, K. L. Black et al., *NCHRP Report No. 346: Implementation Strategies for Sign Retroreflectivity Standards*, Transportation Research Board (April 1992) (Ex. 1012); Joseph T. Fitzpatrick, *Unified Reflective Sign, Pavement and Delineation Treatments for Night Traffic Guidance*, Highway Research Board Bulletin, Issue No. 255 (1960) (Ex. 1017).

21. A different way to create a retroreflective surface is to use glass beads embedded in the surface. The same effect is accomplished: light coming into the glass bead is refracted (bent) as it enters the bead, reflects off of the back of the bead, and is refracted again as it emerges from the front of the bead, returning on a more-or-less parallel path. This is shown in the diagram below. Since the reflection at the back of the bead is on the border between the glass and whatever substrate is behind the glass, the reflected light can pick up the color of the substrate. Glass

beads are typically used in retroreflective lane markings, as it is easier to apply them to a painted line than it would be to create corner cube shapes on the paint.



22. Both of these methods of creating retroreflectivity can deteriorate over time. Corner cubes can become worn or filled with dirt or the layer of the sign containing the corner cubes can become delaminated from the sign backing, for example. Glass beads can be worn away by traffic, weather, or snow plows, for example. Accordingly, it is important to do periodic inspection to ensure that the signs and lane markings are bright enough to meet the minimum standards required for visibility.

23. The most accurate measurement of retroreflectivity would require a calibrated light source, no other external lighting, an accurately measured distance, and a calibrated photosensor to measure the returned light. The raw materials for signs can be measured in this fashion in a lab. Doing the same measurements in the field, on an installed sign or line, is more challenging. One known method uses a hand-held device that can be held to touch the sign: the distance is then set by the size of the instrument, and external light is blocked by the instrument's shape. This method is slow and potentially dangerous to the workers doing the inspection, and

is not viable for inspecting painted lines and raised pavement markings without closing down roads.

24. Another known method approximated the ideal conditions by taking measurements from a moving vehicle at night with known headlights or another known light source and corresponding photosensor. Taking measurements at night reduced the external illumination compared to the daytime. Alternatively, other known methods pulsed a very bright strobe light and timed the photosensor's data collection to match the timing of the light pulse, which allowed measurements from a moving vehicle during daytime by illuminating the reflective object at a much greater intensity than the ambient illumination. Both types of mobile systems typically either included a measurement device to tell how far away the reflective object was or approximated the distance by directing the light source at a fixed angle towards the pavement with a shallow field of view.

25. Additionally, if the photosensor collected two readings, one with the pulse on and one with it off, and subtracted the two readings, the result would be just the active illumination with the background subtracted. This same technique also works with a constant light source by subtracting a reading from just the road without a reflective object (the background) from the reading with the reflective object. My group used this technique in building a light-stripe sensor to detect

curbs and potholes near the vehicle, in full sun, without any special retroreflective properties of the surfaces.

IV. MATERIALS CONSIDERED

26. In forming my opinions, I have analyzed the following exhibits, including the '255 patent, its prosecution history, and the prior art cited in my analysis of the Petition Grounds, as well as the other materials cited in this declaration.

Exhibit	Description
Ex. 1001	U.S. Patent No. 9,335,255 (“the ’255 patent”)
Ex. 1002	Prosecution History of the ’255 patent
Ex. 1005	U.S. Patent Application Publication No. 2002/0063638 to Gallagher (“Gallagher”)
Ex. 1006	U.S. Patent No. 5,796,094 to Schofield et al. (“Schofield”)
Ex. 1007	U.S. Patent No. 5,202,742 to Frank et al. (“Frank”)
Ex. 1008	American Society for Testing and Materials D4383–96, Standard Specification for Plowable, Raised Retroreflective Pavement Markers (July 1996) (“ASTM”)
Ex. 1010	International Publication No. WO 96/17258 to Popovich (“Popovich”)
Ex. 1012	K.L. Black et al., <i>NCHRP Report No. 346: Implementation Strategies for Sign Retroreflectivity Standards</i> , Transportation Research Board (Apr. 1992) (“Black”)
Ex. 1013	U.S. Patent No. 6,359,274 to Nixon et al. (“Nixon”)
Ex. 1014	John J. Lumia, <i>A Mobile System for Measuring Retroreflectance of Traffic Signs</i> , Optics, Illumination, and Image Sensing for Machine

Exhibit	Description
	Vision V, Donald J. Svetkoff, Editor, Proc. SPIE 1385, pp. 15-26 (1991) (“Lumia”)
Ex. 1016	V.J. Pezoldt et al., <i>Raised Pavement Marker Reflectivity</i> , Report No. TX-90/1151-1F, Texas Transportation Institute (Nov. 1990)
Ex. 1017	Joseph T. Fitzpatrick, <i>Unified Reflective Sign, Pavement and Delineation Treatments for Night Traffic Guidance</i> , Highway Research Board, Bulletin 255 (1960) (“Fitzpatrick”)
Ex. 1018	U.S. Patent No. 5,162,643 to Currie (“Currie”)
Ex. 1019	Hugh W. McGee et al., <i>An Implementation Guide for Minimum Retroreflectivity Requirements for Traffic Signs</i> , Report No. FHWA-RD-97-052 (Apr. 1998) (“McGee”)
Ex. 1020	U.S. Patent No. 4,721,389 to Dejaiffe (“Dejaiffe”)

27. My opinions are based on my experience, knowledge of the relevant art, the documents identified above, and the documents discussed in this declaration.

V. LEGAL STANDARDS

28. I am not a lawyer. My understanding of the legal standards to apply in reaching the conclusions in this declaration is based on discussions with counsel for Petitioner, my experience applying similar standards in other patent-related matters, and my reading of the documents submitted in this proceeding. In preparing this declaration, I sought to faithfully apply these legal standards to the Challenged Claims.

A. Claim Construction

29. I have been instructed that the terms appearing in the '255 patent should be interpreted in view of the claim language itself, the specification, the prosecution history of the patent, and any relevant extrinsic evidence. The words of a claim are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art at the time of the invention, which I am assuming here is August 12, 2000. While claim limitations cannot be read in from the specification, the specification is the single best guide to the meaning of a disputed term.

30. I have been instructed that certain elements in a patent claim may be expressed as a means for performing a specified function without the recital of structure, material, or acts in support and that such a claim is construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof. I have been instructed that a claim element that recites the word “means” is presumptively construed as a means-plus-function term.

31. I have followed these principles in reviewing the claims of the '255 patent and forming the opinions set forth in this declaration.

B. Level of Ordinary Skill

32. I understand a person of ordinary skill in the art is determined by looking at (i) the type of problems encountered in the art; (ii) the prior art solutions

to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field.

33. In my opinion, based on these factors, a person of ordinary skill in the art (“POSITA”) would have had at least a bachelor’s degree in mechanical engineering, electrical engineering, computer science, physics, or related discipline, and four years of experience in research, design, or development in computer vision systems. Higher levels of education may offset less experience and extensive experience can substitute for formal education.

34. I was at least a POSITA as of August 12, 2000, and supervised others who were at least a POSITA.

C. Obviousness

35. I have been told that under 35 U.S.C. § 103, a patent claim may be obvious if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.

36. I have been told that a proper obviousness analysis requires the following:

- a. Determining the scope and content of the prior art;

- b. Ascertaining the differences between the prior art and the claims at issue;
- c. Resolving the level of ordinary skill in the pertinent art; and
- d. Considering evidence of secondary indicia of non-obviousness (if available).

37. I have been told that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of invention. For purposes of my analysis, I assumed that the date of invention for the Challenged Claims is August 12, 2000.

38. I have been told that a reference may be modified or combined with other references or with the person of ordinary skill's own knowledge, if the person would have found the modification or combination obvious. I have also been told that a person of ordinary skill in the art is presumed to know all the relevant prior art, and the obviousness analysis may take into account the inferences and creative steps that a person of ordinary skill in the art would employ.

39. I have been told that whether a prior art reference renders a patent claim obvious is determined from the perspective of a person of ordinary skill in the art. I have also been told that, while there is no requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed

invention, and while a suggestion to combine known elements to achieve the claimed invention may come from the prior art as a whole or individually and may consider the inferences and creative steps a person of ordinary skill in the art would employ, as filtered through the knowledge of one skilled in the art, obviousness grounds cannot be sustained by mere conclusory statements and must include some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.

40. I have been told that there is no rigid rule that a reference or combination of references must contain a “teaching, suggestion, or motivation” to combine references. But I also have been told that the “teaching, suggestion, or motivation” test can be used in establishing a rationale for combining elements of the prior art. I have also been told to be aware of distortions caused by hindsight bias, and that reading into the prior art the teachings of the invention at issue is improper.

41. I am aware that a claim may be obvious where the claim represents nothing more than a combination of prior art elements according to understood methods that yields predictable results. I am further aware that a claim may be obvious where it merely involves the simple substitution of one known element for another to achieve predictable results. I am additionally aware that it may be obvious to try a particular combination of claim features if selecting them requires

merely choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success.

42. I have been informed that, in an obviousness analysis, prior art must be analogous art to the patent being considered. I have been informed that a prior art reference is considered to be analogous, or in the same field of art, if the reference is either (1) in the same field of endeavor as the challenged patent, regardless of the problems the challenged patent and the prior art address, or (2) reasonably pertinent to the particular problem being solved by the challenged patent.

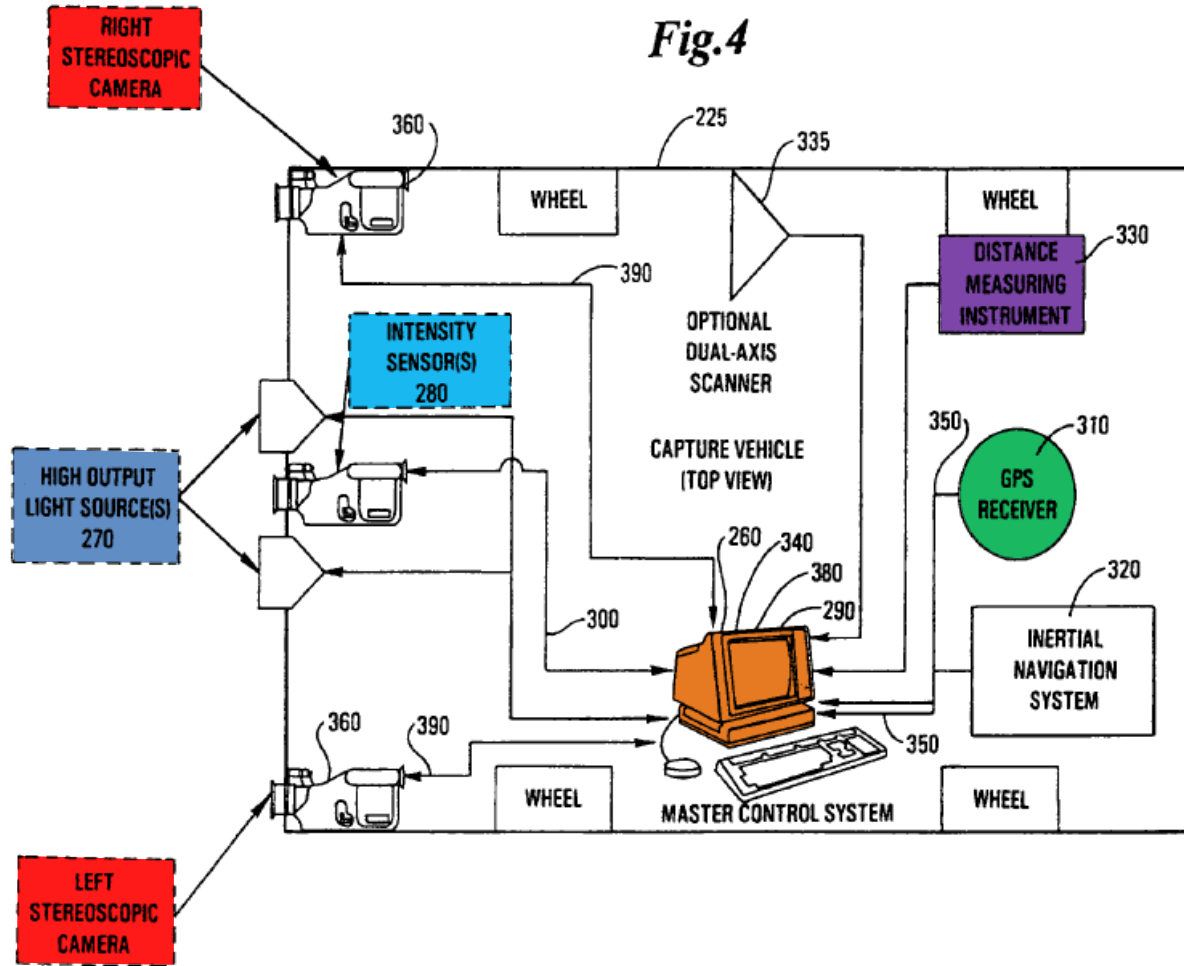
VI. THE '255 PATENT

A. Specification

43. The '255 patent discloses a system for assessing reflective surfaces along a roadway. Ex. 1001, Abstract. The '255 patent admits that “using an automated image identification system to recognize road signs and traffic signs [was] well known,” but asserts that proposed systems used less accurate “template matching of shape and color.” Ex. 1001, 1:36-42. The '255 patent states that those inaccuracies are due to “the wide variations in lighting and conditions.” Ex. 1001, 1:42-44.

44. Like the known prior art, the '255 patent's system determines “retroreflectivity values for reflective surfaces disposed along a roadway” using

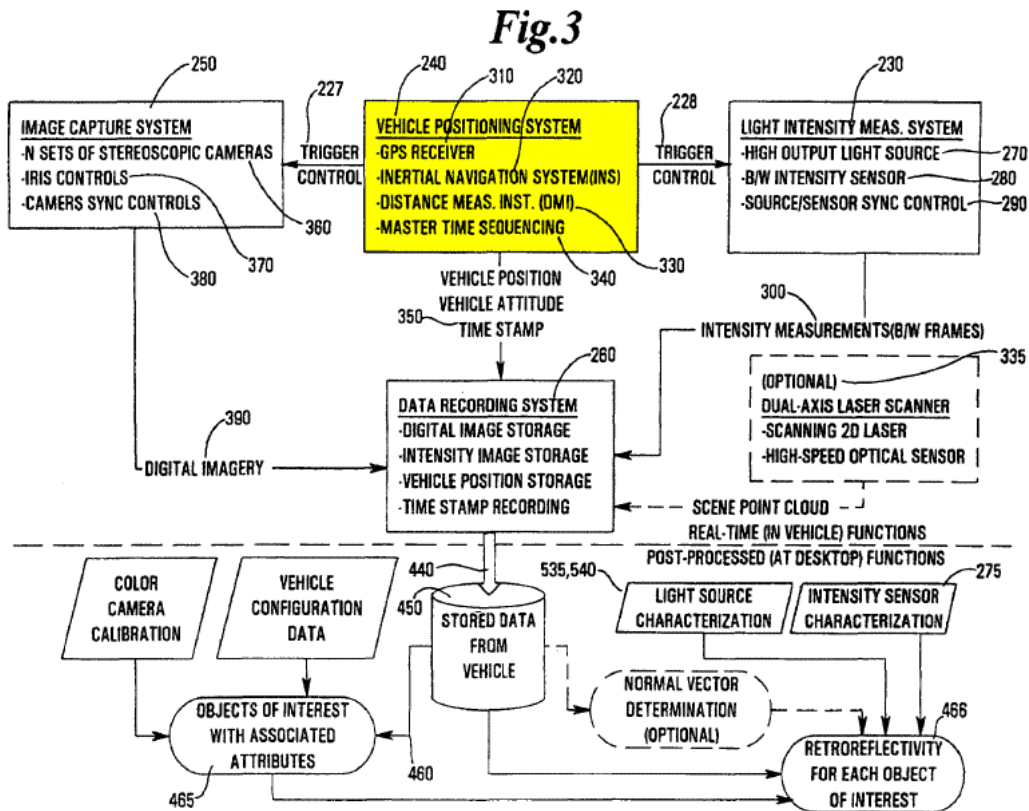
“subsystems located on/in a capture vehicle 225.” Ex. 1001, 3:60-65, 7:57-8:8. As was well known by a POSITA, retroreflectivity is the ability of an object to reflect light back to its source. *E.g.*, Ex. 1012 (“Retroreflection occurs when light rays strike a surface and are redirected back to the source of light.”); Lumia, 15-16 (“A retroreflector is a device which turns light back toward its source, usually over a wide range of input angles.”); Ex. 1016 (“Retroreflection is the ability of a device to return light in directions close to that from which it came.”). Figure 4, annotated below, depicts “a *typical* configuration within a capture vehicle” that can produce “data and imagery to create digital representations of objects of interest” and their retroreflectivity. Ex. 1001, 10:7-10 (emphasis added).



Ex. 1001, Fig. 4 (annotated).

45. A distance measuring instrument 330 and GPS receiver 310 form part of a vehicle positioning system 240 (highlighted in Figure 3, below) that generates position measurements (e.g., position of the vehicle and distance from the vehicle to a road marker). Ex. 1001, 8:1-5, 10:10-16, Fig. 3. A digital imagery system 390, which includes the stereoscopic cameras 360 in the embodiment above, “allows for the creation of objects of interest 460 and their associated attributes 465 during post-processing.” Ex. 1001, 10:24-27. The ’255 patent acknowledges that “[t]here

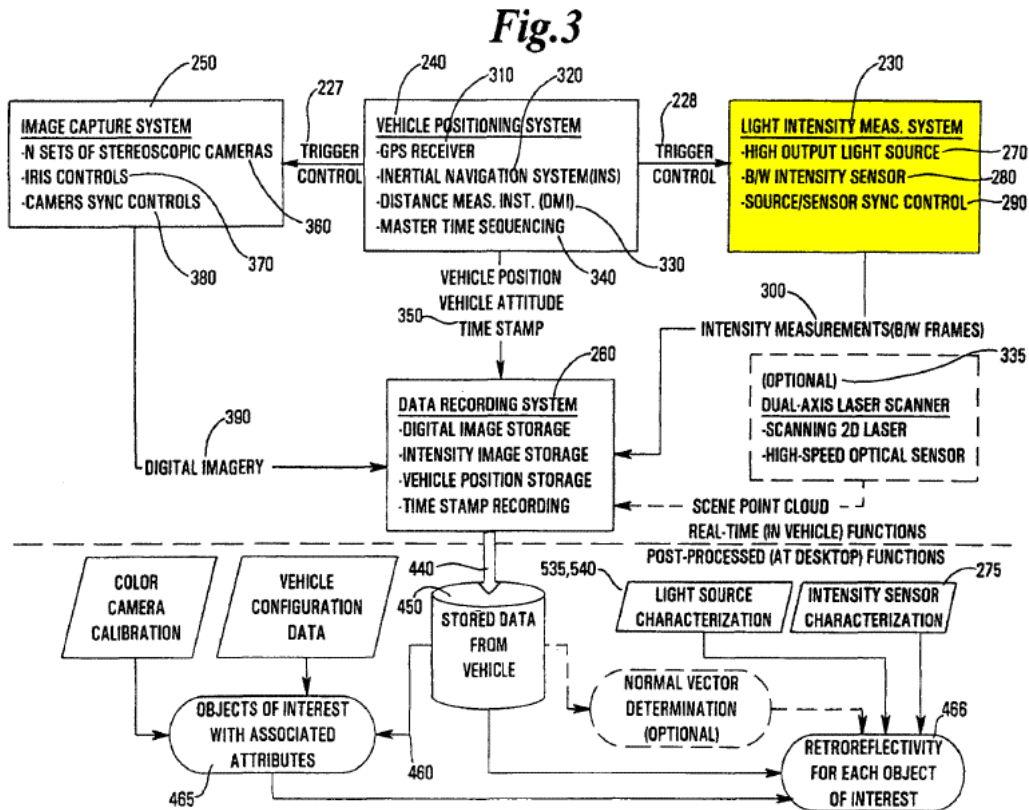
are many methods for creating objects of interest 460 from digital imagery” and assumes that a POSITA would have been aware of other such methods, as it states that only “a few of [the methods] are discussed in” the ’255 patent. Ex. 1001, 10:3-6.



Ex. 1001, Fig. 3 (annotated).

46. “The high output light source(s) 270 and light intensity sensor(s) 280 constitute the light intensity measurement system 230.” Ex. 1001, 7:62-65, 10:17-23. Light intensity measurement system 230 (highlighted in Figure 3, below) generates intensity measurements “in response to the repeated strobing of the high output light source 270,” which makes it possible to collect the data needed to

compute retroreflectivity. Ex. 1001, 7:65-8:1, 10:17-23. The number of intensity values in each intensity measurement can correspond to “the number of pixels in the light intensity sensor’s 280 array.” Ex. 1001, 11:27-33.



Ex. 1001, Fig. 3 (annotated).

47. The master control system (unlabeled) monitors the other onboard systems and records the data for post-processing by “desktop systems” to identify objects of interest and their retroreflectivity. Ex. 1001, 8:5-48, 9:4-10:6, Fig. 3.

48. The '255 patent discloses that intensity is “determined from the gray value of the corresponding pixels” in the image of the light intensity sensor 280. Ex. 1001, 11:24-27. “Intensity values will vary according to the color of the

reflected light, since not all colors of incoming light excite the light intensity sensor 280 pixels in the same way.” Ex. 1001, 11:41-43. “By knowing the background or foreground color of the object of interest” and the intensity sensor’s profile for a particular color, “the intensity value 300 for a particular color can be converted into a luminance value.” Ex. 1001, 11:43-48. With a “uniform light source,” knowing the luminance and the distance to the object of interest allows the retroreflectivity to be approximated. Ex. 1001, 11:61-12:8.

49. The ’255 patent discloses using its system for determining retroreflectivity “to detect and determine a retroreflective surface of interest disposed in a scene of non-retroreflective surfaces.” Ex. 1001, 8:60-9:3. The ’255 patent discloses that “road sign[s]” and “pavement markings” include reflective surfaces whose retroreflectivity may be measured. Ex. 1001, 3:60-65, 17:26-18:30.

50. Notably, none of the ’255 patent’s techniques for determining reflectivity laid out in its “Summary of the Invention,” reproduced below, are recited in the challenged claims.

SUMMARY OF THE INVENTION

The present invention is a system for classifying different types of sheeting materials of road signs depicted in a video-stream. Once a road sign has been identified in the video-stream, the frames associated with that road sign are analyzed to determine each of a plurality of colors present on the road sign. An estimated retroreflectivity for each of the plurality of colors present on the road sign is then determined. By comparing the estimated retroreflectivity for each of the plurality of colors against known minimum retroreflectivity values for the corresponding color for different types of sheeting materials, an accurate determination of the classification of the sheeting material of the road sign is established. Preferably, certain conditions of gross failure of the sheeting material are filtered out before classification of the sheeting material is determined.

In a preferred embodiment, a system for the automated determination of retroreflectivity values for reflective surfaces disposed along a roadway is utilized to establish the retroreflectivity values for both foreground and background colors of a road sign for the purpose of classifying the sheeting material of that sign. An area along the roadway that includes at least one reflective surface is repeatedly illuminated by a light source and multiple light intensity values are

measured over a field of view which includes at least a portion of the area illuminated by the light source. A computer processing system is used to identify a portion of the light intensity values associated with a reflective surface and analyze the portion of the light intensity values to determine at least one retroreflectivity value for that reflective surface. Color images of the area and locational information are also generated by the system and are used together with a characterization profile of the light source to enhance the accuracy of the determination of retroreflectivity values.

In contrast to the existing techniques for determining retroreflectivity that require an operator to target individual signs from a known distance, a preferred embodiment of the present invention can determine retroreflectivity without targeting individual signs and can automatically determine sheeting classification as a result. To overcome the limitations imposed by the existing techniques, the preferred embodiment employs several enhancements that are designed to improve the accuracy of evaluating intensity measurements made over a view where the reflective surfaces are not individually targeted and therefore neither the distance to the reflective surface or the normal vector to the reflective surface are known.

B. Prosecution History

51. The '255 patent was filed as Application No. 14/512,735. Following a preliminary amendment, the Examiner rejected claims 20 and 31 (which correspond to claims 1 and 12 of the '255 patent) for obviousness-type double patenting over claim 19 of U.S. Patent No. 8,660,311, and claim 20 of U.S. Patent No. 8,860,944, respectively. Ex. 1002, 211-214. Applicant filed terminal disclaimers for each patent. Ex. 1002, 229-232, 236. The Examiner then issued a

notice of allowance, stating that “the prior art fails to disclose or make obvious” the claimed combination of features in each independent claim. Ex. 1001, 290-293.

VII. Claim Construction

52. In my opinion, the ’255 patent recites one means-plus-function term and have proposed a construction for this term below based on the legal principles on which I have been instructed. For all other terms, it is my opinion that the plain meaning should apply for the purpose of this IPR because the prior art falls within the unambiguous scope of the claims.

A. “means for determining a plurality of light intensity values directed to cover a field of view which includes at least a portion of the area illuminated by the light source”

53. This term recites the word “means” without any corresponding structure, so I believe it should be construed as a means-plus-function term with the following function and corresponding structure:

- Function: “determining a plurality of light intensity values directed to cover a field of view which includes at least a portion of the area illuminated by the light source”;
- Structure: a light sensor, or equivalents. Ex. 1001, 20:53-55.

54. The structure of “light sensor” is supported, for example, by dependent claim 23, which states that “the means for determining a plurality of light intensity values comprises a light sensor.” Ex. 1001, 20:53-55. This structure

is also consistent with the specification, which repeatedly refers to a “light intensity sensor 280.” *E.g.*, Ex. 1001, 7:62-65, 10:17-19, 11:21-60. For example, the “light intensity sensor 280” is part of a “light intensity measurement system 230,” where each intensity measurement includes “intensity values for N discrete points within the scene, where N corresponds to the number of pixels in the light intensity sensor’s 280 array.” Ex. 1001, 7:62-65, 11:27-33.

VIII. OVERVIEW OF THE PRIOR ART

A. Gallagher (Ex. 1005)

55. Gallagher, like the ’255 patent, discloses a “reflectivity measuring apparatus” used on a moving vehicle. Gallagher, [0001], [0031]-[0033]. Gallagher discloses that “[l]ight reflective road markings and markers are extensively used to demarcate vehicle lanes and supply vital information to drivers about sections of road” and “function by reflecting or retroreflecting light rays entering the reflective material of the road marking back to a driver.” Gallagher, [0002]. Gallagher’s apparatus tests “road markings and road markers such as, for example, road signs and posts, reflective painted lines whether continuous or broken, and ... raised pavement markers” “to ensure they continue to meet minimum standards of reflectivity/retroreflectivity.” Gallagher, [0003], [0006], [0031]-[0033]. It overcomes the disadvantages of then-conventional test methods that relied on

subjective “night time drivebys using headlights” or a labor-intensive “portable hand held measuring instrument.” Gallagher, [0003]-[0006].

56. Gallagher’s apparatus “is mounted on ... a vehicle 3” and “can obtain reflectivity measurements, inter alia, with the vehicle 3 travelling at speeds of up to about 100 kph.” Gallagher, [0032]. “For simplicity,” Gallagher describes an embodiment that measures “raised pavement markers 2,” referred to as “markers,” but it can also “be adapted to measure other types of reflective markings on or adjacent [to] the road.” Gallagher, [0033]. Gallagher’s apparatus includes “a light source 4 in the form of a standard vehicle headlight” with a “relatively constant and even intensity.” Gallagher, [0035]. “A reflected light results from the beam illuminating” a surface of marker 2, and “[a] light sensor 6 detects the reflected light.” Gallagher, [0036], [0038], [0046]. Sensor arrays containing multiple sensors, each “arranged to detect reflected light from a relatively small viewing angle,” “are advantageously aligned in an encased module 6a to increase the field of view of the apparatus 1.” Gallagher, [0038], [0040]. The sensors may be “photodiodes mounted precisely on the module 6a at a height and angle to properly detect reflected light” and may be configured to “indicate the [color] of a road marking being tested.” Gallagher, [0039]. The light source 4 and light sensor module 6a are mounted in close proximity “to reduce the observation angle to almost zero.” Gallagher, [0041]. This apparatus is depicted in Figure 1, below.

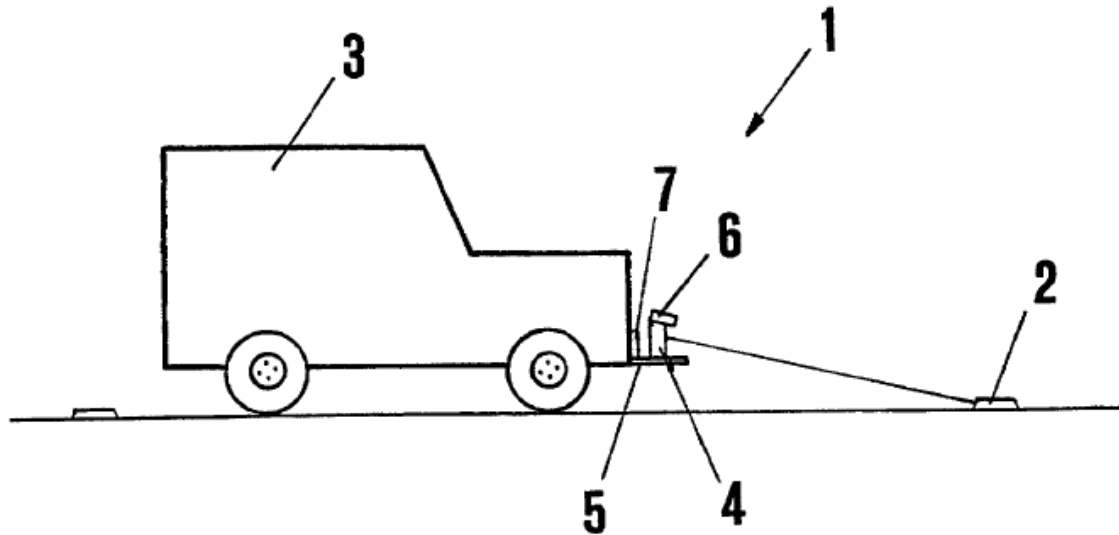


Figure 1

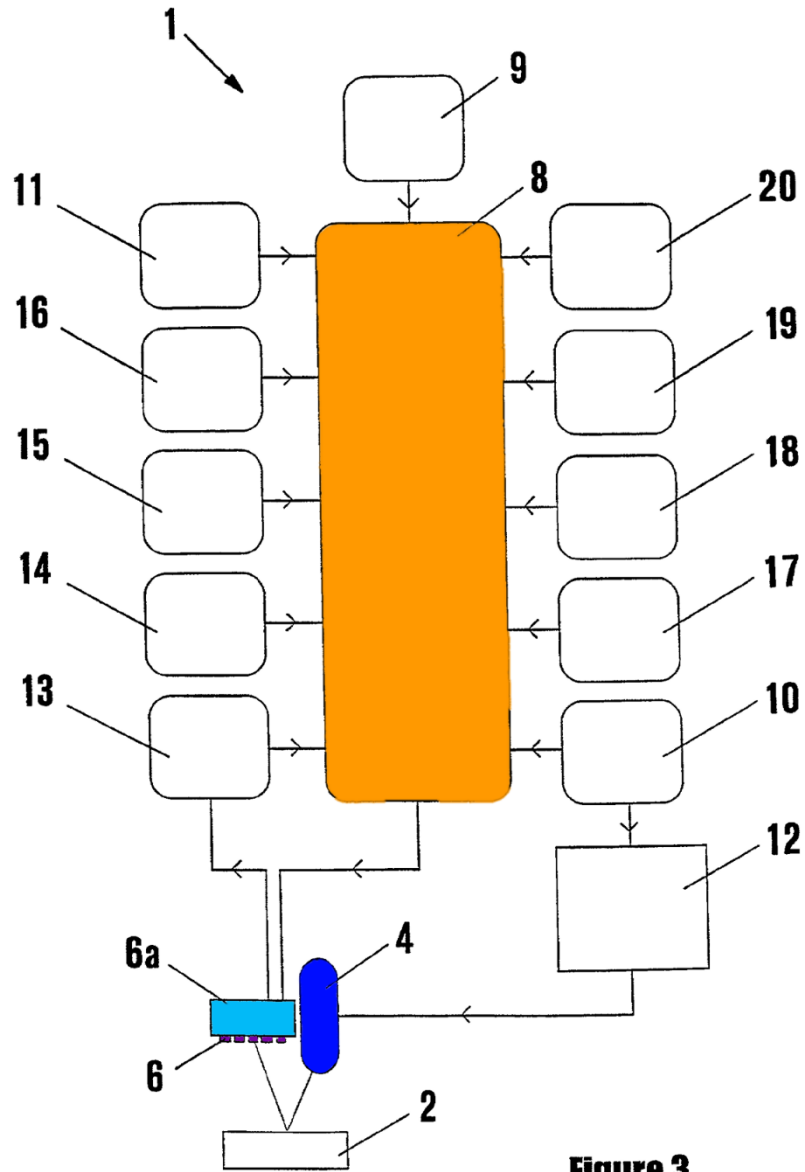
Gallagher, Fig. 1.

57. The apparatus also includes “a computer 8 ... to carry out a method of testing the integrity of road markings.” Gallagher, [0045]. Computer 8’s processing includes “getting the data ... on the reflected light detected by the light sensors 6,” “calculating the average reflectance level from a set of sampled data from each sensor,” “calibrating the data by multiplying the data with a predetermined calibration factor to calibrate for different positions in the light sensor module 6a,” “determining the distance travelled from the start position of the road marking test so as to determine the location of each road marking,” “determining the background reflectance level on the road and establishing non-marker reflectance levels,” “selecting ... which reflectance levels indicate a road marker,” “determining the reflectance level of the road marker in a value of millicandela per

Lux (CIL),” and “tagging ... a road marker if it is determined as measuring a reflectivity less than the predetermined minimum acceptable reflectance level.”

Gallagher, [0055]-[0068]. “The data obtained on the reflectance level and location of each road marking tested can be stored and later used in a rerun of a stretch of road tested earlier.” Gallagher, [0073]. Gallagher’s apparatus also provides “an audio and/or visual indicator” of the vehicle’s position on the road to the driver to help the driver “maintain the vehicle 3 in a proper position on the road to allow the apparatus 1 to obtain reflectivity measurements.” Gallagher, [0060]-[0062].

58. Figure 3, below, highlights the reflectivity measuring apparatus’ light source 4, its array 6a of light sensors 6, and its computer 8. Gallagher, [0035]-[0050], Fig. 3.



Computer
Light Source
Light Sensor Array / Sensors

Gallagher, Fig. 3 (annotated).

59. Gallagher is analogous art to the '255 patent because it is in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:29-30; Gallagher, [0007], [0066], [0078]. Gallagher is also analogous art to the '255

patent because it is reasonably pertinent to problems addressed by the '255 patent, including automatically identifying road markers without relying solely on “template matching of shape and color.” Ex. 1001, 1:36-44; Gallagher, [0066] (identifying road markers based on “peak responses sensed” by light sensors).

B. Lumia (Ex. 1014)

60. Lumia discloses a mobile system that “can measure the average retroreflectance of sign legend and background from a moving vehicle during daylight hours.” Lumia, 15. “This system uses a video camera to acquire sign images, a xenon flash as a source of light, a personal computer to analyze the sign images, and a laser rangefinder to measure the distance to the sign.” Lumia, 15.

61. Lumia’s system was design was designed to measure the retroreflectance of traffic signs formed from “retroreflective sheeting.” Lumia, 15. Lumia explains that retroreflectance (R) can be calculated from the “the luminance of the reflected light” (L) and “the normal illumination incident on the retroreflector,” which is estimated using the intensity of the light source (I) and “the distance from the source to the detector” (d). Lumia, 15-16. This retroreflectance calculation results in the following equation:

$$R = \frac{L \cdot d^2}{I}$$

Lumia, 15-16.

62. To carry out retroreflectance measurements on both the legend and background of traffic signs, Lumia's system uses "a video camera to record the sign," "an electronic flash source to provide a short burst of light sufficiently bright enough to overcome the sign luminance due to ambient daylight illumination," "a laser rangefinder" to measure the distance from the vehicle to the sign, and a computer to process images from the video camera and calculate the retroreflectance of a sign's legend and background. Lumia, 15. Figures 4 and 5, below, illustrate Lumia's system. Lumia, 17.

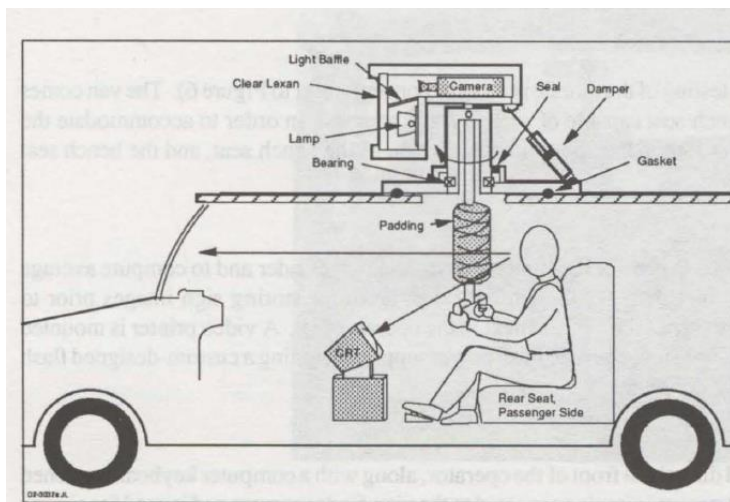


Figure 4. Conceptual design of MSMRTS mobile prototype.

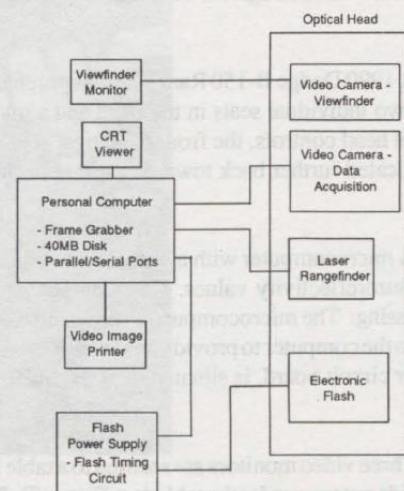
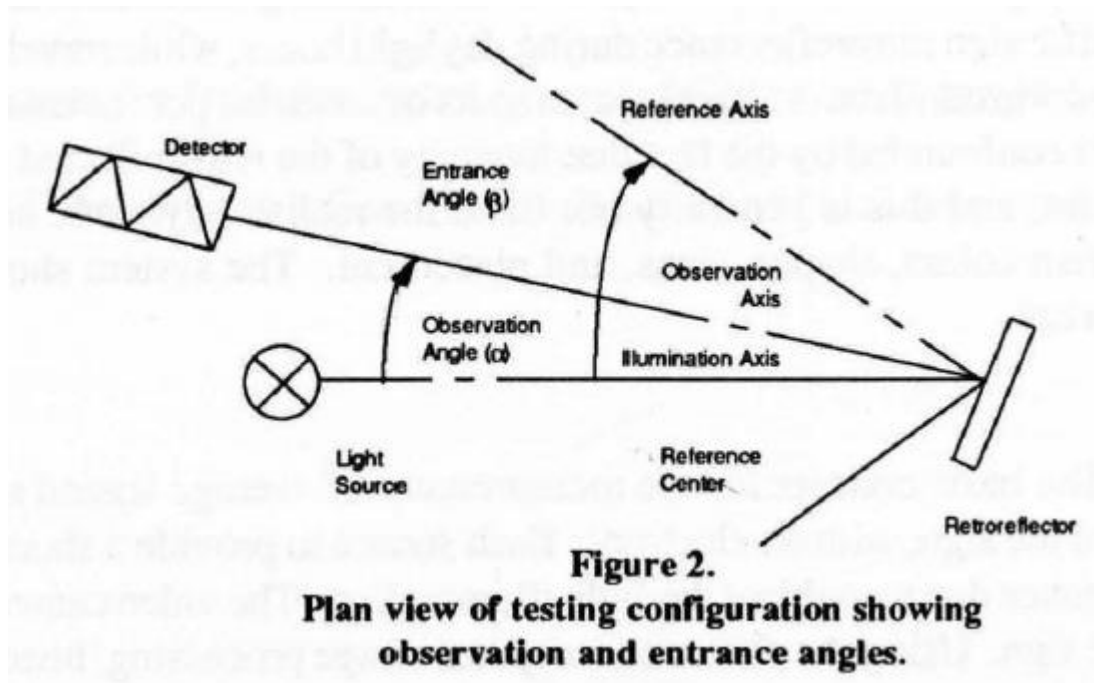


Figure 5. Block diagram of MSMRTS mobile prototype.

Lumia, Figs. 4-5.

63. Lumia recognized that the retroreflectance values change, depending on the "observation angle" and "entrance angle," making attention to these angles "important since, in general, all retroreflective devices do not behave the same as

the geometry is changed.” Lumia, 21. These angles are depicted in Figure 2, reproduced below, which shows “the commonly accepted geometry and definitions ... for evaluating retroreflective materials.” Lumia, 16.



Lumia, Fig. 2.

For example, Figure 9, below, depicts the relative retroreflectance of different materials as a function of observation angle. Lumia, 21. “The effect of entrance angle (the angle between the axis of the light source and the normal to the sign) is far less severe.” Lumia, 21.

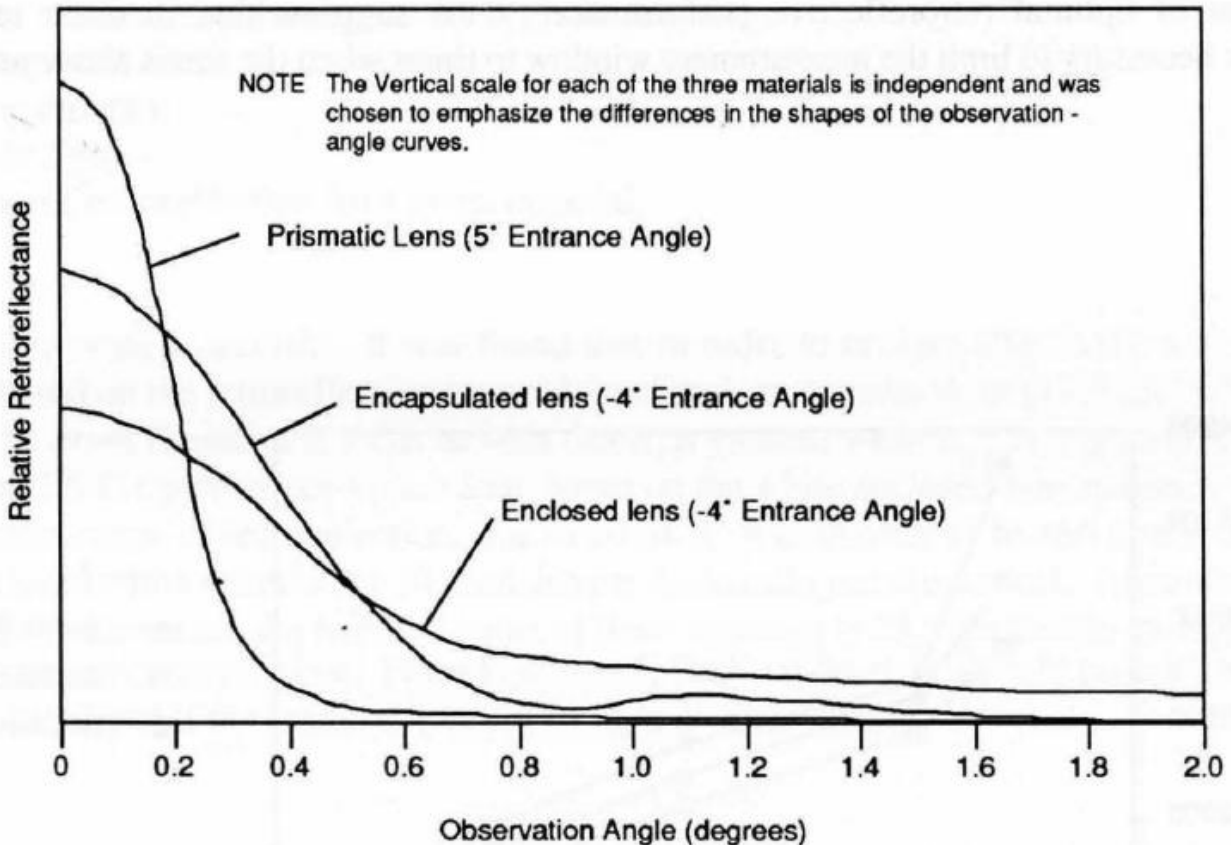


Figure 9. Relative retroreflectance versus observation angle.⁴

Lumia, Fig. 9.

64. When the distance between the light source and light detector is fixed, “the observation angle increases with decreasing distance to the sign.” Lumia, 21. Because “the material of the sign being measured will most likely not be known, ... it will be nearly impossible to relate the measured [retroreflectance] value to a commonly measured observation angle (such as 0.2°).” Lumia, 21. As a result, Lumia recognizes a “‘distance window’ in which the measurements need to be taken” to be sufficiently accurate. Lumia, 21. “The use of a laser rangefinder in a

moving system provides an accurate measure of monitoring the distance from the vehicle to the sign and triggering image acquisition when a predetermined sign distance is reached.” Lumia, 15.

65. Lumia is analogous art to the ’255 patent because it is in the same field of endeavor, namely an automated determination of retroreflectivity values for reflective surfaces disposed along a roadway. Ex. 1001, 3:60-65; Lumia, 15-16. Lumia is also analogous art to the ’255 patent because it is reasonably pertinent to problems addressed by the ’255 patent, including providing a device that overcomes “sending personnel in the field to measure retroreflectivity with a handheld device.” Ex. 1001, 1:61-2:51; Lumia, 15-16 (measuring retroreflectivity of a sign from a moving vehicle).

C. Schofield (Ex. 1006)

66. Schofield discloses a system that “identifies particular light sources” by “separating each light source” in a forward scene of a vehicle and “analyzing that source to determine its characteristics,” including its spectral characteristics and spatial layout. Schofield, 1:56-67, 2:6-14. Light sources include “[l]ane markers, signs, and other sources of reflected light.” Schofield, 10:43-45. Schofield discloses using its system to “identify particular traffic signs” and “detect lane markers,” among other light sources. Schofield, 12:1-4, 12:40-42.

67. Schofield's system includes "an imaging sensor module 14 which senses light from a scene forward of vehicle 10" and "an imaging control circuit 13 which receives data from sensor 14." Schofield, 3:36-44. "Imaging sensor module 14 includes an optical device 36, such as a lens, an array 38 of photon-accumulating light sensors, and a [filter array 40] for separating light from the scene forward of vehicle 10 into a plurality of spectral bands." Schofield, 4:16-21. The "array 38 may be a charge couple device (CCD) array of the type commonly utilized in video camcorders and the like" and may include an array of "light-sensing pixels, each made up of a photosensor element 42." Schofield, 4:28-31, 8:38-40, Fig. 4.

68. The imaging control circuit 13 "responds to the plurality of sensors in order to determine if spatially adjacent regions of the field of view forward of the vehicle include light of a particular spectral signature above a particular intensity level." Schofield, 2:28-32, 4:47-5:12, 7:64-8:12. Analyzing the intensity values of each of the red, green, and blue pixels in the array both relative to each other and relative to a particular intensity range "helps to reduce false detection of light sources." Schofield, 7:64-8:8. Schofield's control circuit also uses "spatial filtering" and "[p]attern recognition" to further assist in identifying objects of interest. Schofield, 10:51-11:3. Spatial filtering refers to considering "whether a particular pixel, or pixel group, is detecting a light source having a particular

spectral signature” and “what adjacent, or closely related, pixels or pixel groups, are detecting.” Schofield, 10:53-57. “Pattern recognition identifies objects of interest based upon their shape, reflectivity, luminance, and spectral characteristics.” Schofield, 11:1-3.

69. Schofield’s system is used to identify “point sources of light in any particular location within the scene viewed forward of the vehicle” and “at great distances.” Schofield, 9:24-26, 10:22-26. For example, Schofield discloses using its system “to identify particular traffic signs by their spectral signature as well as their geometric organization” (e.g., identifying red octagons as stop signs or yellow triangles as caution signs). Schofield, 12:1-4. Schofield attributes this ability to the “significant reduction in the amount of data to be processed because the image forward of the vehicle is captured in a manner which preselects data” using the spatial and spectral light-source characteristics. Schofield, 12:5-11. Schofield also discloses using its system “to detect lane markers ... to either assist in steering the vehicle or provide a warning to the driver that a lane change is occurring.” Schofield, 12:40-42.

70. Schofield is analogous art to the ’255 patent because it is in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:29-30; Schofield, 1:56-2:15, 9:24-26. Schofield is also analogous art to the ’255 patent because it is reasonably pertinent to problems addressed by the ’255 patent,

including automatically identifying road markers without relying solely on “template matching of shape and color.” Ex. 1001, 1:36-44; Schofield, 10:66-11:12 (using various characteristics, including “reflectivity,” for object identification).

D. Frank (Ex. 1007)

71. Frank discloses “a laser radar system capable of accurately measuring the distance and angle between a vehicle and a retroreflector located ahead at or near the road surface at some distance ahead of the vehicle.” Frank, 3:8-12. Frank’s apparatus “may be mounted in any location on the vehicle where the apparatus can be provided with a view of at least one retroreflector ahead of the vehicle.” Frank, 4:45-51. Frank’s apparatus “calculates the distance D between vehicle 101 to the retroreflector and the angle θ formed between axis 104 and an imaginary line drawn between vehicle 101 and a retroreflector, for example[,] retroreflector 114,” as depicted below. Frank, 4:37-42. “[T]he retroreflectors may be standard roadway reflectors embedded in the roadway” or “may be mounted at another location near the roadway,” such as “on posts.” Frank, 6:53-55, 7:13-18.

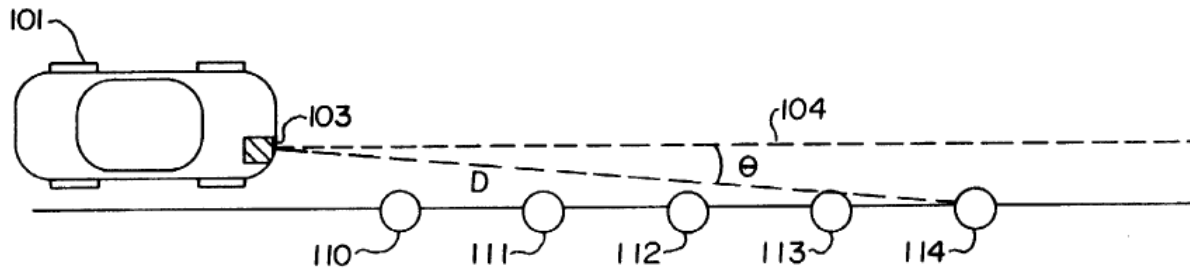


FIG. 2

Frank, Fig. 2.

72. Frank's apparatus includes a laser 332 producing a light beam 336 that "passes through cylindrical lens 331 to produce fan beam 339," which is "very thin but broadens at a predetermined angle forming a triangular or fan shaped beam." Frank, 4:52-5:7. "Fan beam 339 is reflected from mirror surface 330 and is directed towards roadway 102" Frank, 5:7-9. The angle of mirror surface 330 oscillates through a range, causing "fan beam 339 to scan a particular area." Frank, 5:12-21. Alternatively, Frank's apparatus may instead output a pulse-modulated "floodlight beam 946" covering all of a predetermined area that is similar in size to that covered by fan beam 339. Frank, 10:54-62. Figures 1A and 2A, below, depict the scanned area 447, with a beam angle ω and scanning range α producing "a beam that would scan the area from distance 121 in front of vehicle 101 (approximately 25 feet at the preferred two foot mounting height)" to an effective

distance 122, approximately 130 feet, “due to the attenuation effects of the atmosphere” on the beam. Frank, 6:12-49.

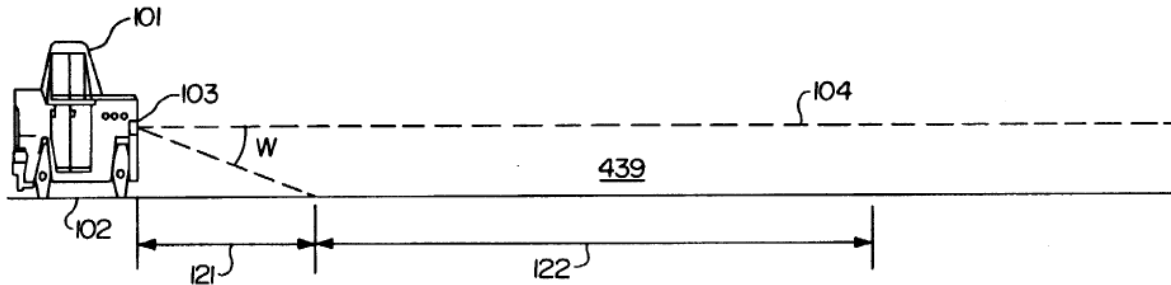


FIG. 1A

Frank, Fig. 1A.

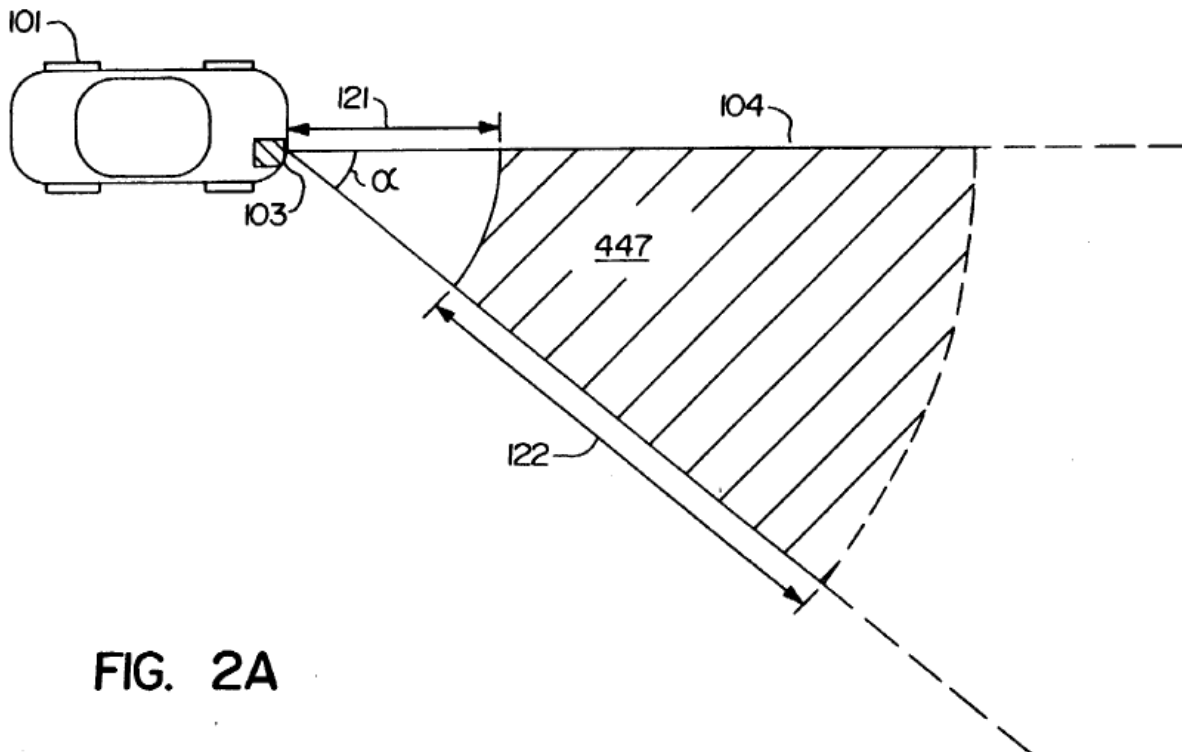


FIG. 2A

Frank, Fig. 2A.

73. Frank's apparatus includes a "receiving apparatus 465," including an optical receiver that "receives the reflected light beams from" all retroreflectors that "fall within a predetermined beam path" and "outputs a corresponding electrical signal to receiver electronics 443," which determines "distance D and angle θ for each retroreflector scanned." Frank, 6:4-7, 7:27-50. "If only reflectors located a certain distance or range from vehicle 103 are of interest, the controller may then subsequently sort such data and use only data of interest to the particular control algorithm." Frank, 6:7-11.

74. Frank is analogous art to the '255 patent because it is in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:29-30; Frank, 6:4-11. Frank is also analogous art to the '255 patent because it is reasonably pertinent to problems addressed by the '255 patent, including automatically identifying road markers without relying solely on "template matching of shape and color." Ex. 1001, 1:36-44; Frank, 7:27-50 (identifying retroreflectors using "reflected light ... transmitted back to [a] laser radar apparatus").

E. Currie (Ex. 1018)

75. Currie discloses "a light detecting system for accurately determining the lateral position of a moving object, such as a vehicle, relative to a point or points in advance of the object's current position along a desired path." Currie, Abstract. Currie discloses a light source 30 that includes "a medium power infrared

light source and an incandescent light source.” Currie, 4:20-34. “[T]he infrared light source is pulsed to permit accurate range detection in a range detection channel,” and “[t]he incandescent light source is used to provide enhanced reflection intensity from reflectors placed along the desired path of vehicle motion.” Currie, 4:34-39.

76. Light reflected from retroreflectors “along a side of the path which the vehicle is to be guided” is directed towards a lens in a “range detection channel” and a lens in an “angle detection channel.” 4:43-48. The lens in the angle detection channel focuses the light on a “charge-coupled device (CCD) array 56,” and each output value from the array is compared to a threshold intensity “above that of typical ambient light or light reflected from surfaces other than the retroreflectors placed along the roadside.” Currie, 5:50-61, 7:1-29. “When the light intensity detected in a particular location (i.e., set of 3 detectors) of the CCD array is determined to exceed the experimentally determined threshold, the angular location of a reflector relative to a reference point on the moving vehicle can be readily determined.” Currie, 7:23-29, 7:38-46.

77. Light received by the lens “in the range detection channel is focused onto a single detector 46,” such as a photosensitive diode. Currie, 5:8-14. Currie’s system “stores a count proportional to the time required for a light pulse to travel from the light source 30 to one of the reflectors and back to the range detection

channel.” Currie, 5:39-49, 4:34-37. This count is used to determine a distance to the retroreflector. Currie, 8:1-32, 9:44-46.

78. Currie is analogous art to the ’255 patent because it is in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:29-30; Currie, 1:7-15, 6:3-20, 6:57-63. Currie is also analogous art to the ’255 patent because it is reasonably pertinent to problems addressed by the ’255 patent, including automatically identifying road markers without relying solely on “template matching of shape and color.” Ex. 1001, 1:36-44; Currie, 8:50-59 (using reflected light to identify reflectors “located on the ground along the roadside” or “on posts next to the roadside”), 9:39-49.

IX. ANALYSIS OF PETITION GROUNDS

79. In my opinion, the Challenged Claims of the ’255 patent would have been obvious over the following grounds.

1	Gallagher renders obvious claims 12-14, 17, 21, and 23
2	Gallagher and Lumia render obvious claims 13 and 15
3	Gallagher and Schofield render obvious claims 18-19
4	Gallagher and Frank render obvious claim 20
5	Gallagher and Currie render obvious claim 22

A. Ground 1: Gallagher Renders Obvious Claims 12-14, 17, 21, and 23

1. Independent Claim 12

a. [12P]: “An automated method of assessing reflective surfaces disposed along a roadway comprising:”

80. While I have been advised that a preamble is not always limiting, I have been asked to assume for the purposes of this Declaration that each of the preambles in the independent claims of the '255 patent is limiting. Gallagher discloses [12P].

81. Gallagher discloses an automated system of assessing reflective surfaces disposed along a roadway using its reflectivity measuring apparatus. Gallagher, [0033]-[0035]. Gallagher's reflectivity measuring apparatus assesses reflective surfaces of road markers because it includes a light source that “illuminates a reflective surface of a” road marker disposed along a roadway, light sensors 6 that detect “the reflected light,” and a computer 8 that obtains data “on the reflected light detected by” light sensors 6 and selects “which reflectance levels indicate a road marker.” Gallagher, [0046], [0055]-[0066]. This system then tags any road markers determined to have “a reflectivity less than the predetermined minimum acceptable reflectance level.” Gallagher, [0068]. This system is automated because, once a measurement process is initiated, measurements

automatically are “made in real time” by the computer. Gallagher, [0046], [0071]-[0072].

- b. [12A]: “activating a light source as the light source is traversed along a roadway to illuminate an area that includes at least one reflective surface on a road marker, the road marker having a reflective characteristic;”**

82. Gallagher discloses or suggests [12A].

83. Gallagher’s reflectivity measuring apparatus is “mounted on a vehicle” and includes “a light source 4.” Gallagher, [0007], [0035]-[0039].

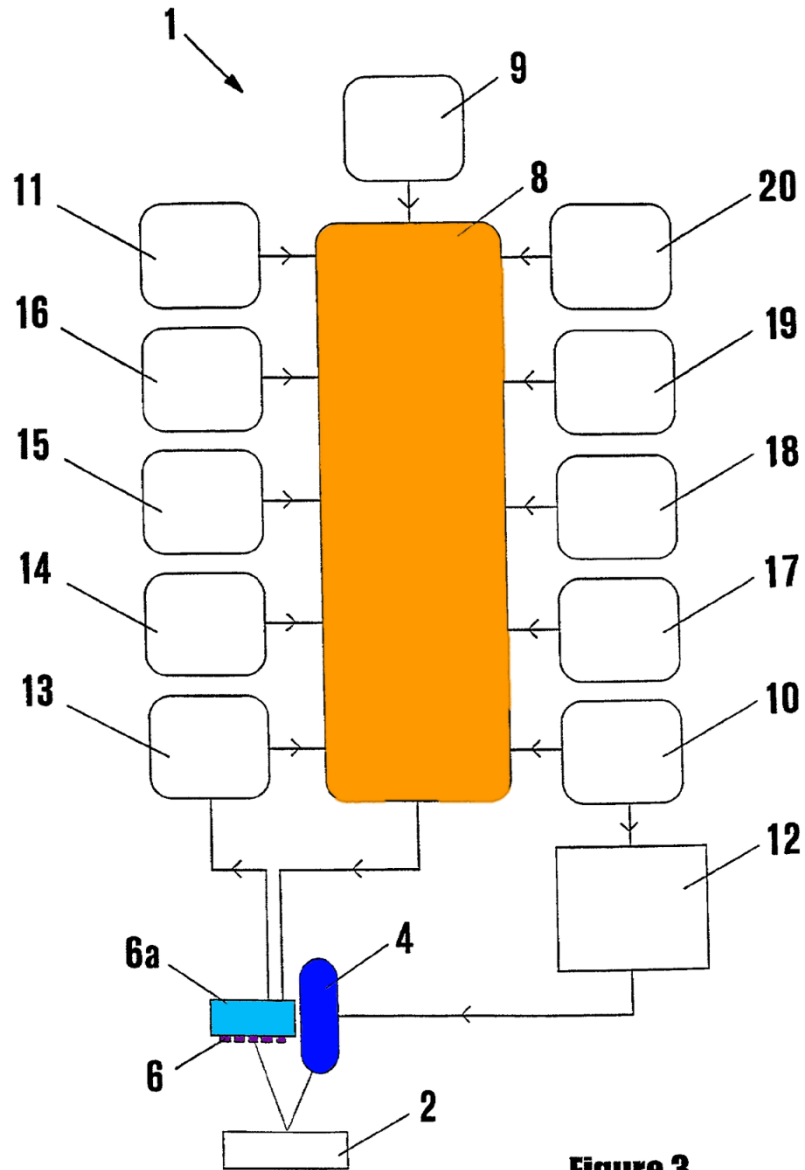


Figure 3

Computer
Light Source
Light Sensor Array / Sensors

Gallagher, Fig. 3 (annotated).

84. Gallagher's light source 4 is traversed along a roadway because it is "mounted on ... a vehicle 3" and measures reflectivity while the vehicle travels "at speeds of up to about 100 kph" (traverses) "on a road" (along a roadway).

Gallagher, [0031]-[0032], Fig. 2 (below). The roadway includes raised pavement markings, for example, that “have two highly reflective surfaces” (at least one reflective surface on a road marker). Gallagher, [0005], [0034]. The apparatus measures the level of reflectivity (a reflective characteristic) of the “road markers.” Gallagher, [0032]-[0033], [0066]-[0068]. Gallagher’s active light sensor can also “be adapted to measure other types of reflective markings on or adjacent [to] the road.” Gallagher, [0033].

85. Gallagher discloses that, as the vehicle—and thus the light source—traverses along a roadway, an operator in the vehicle activates the light source “by sending a signal via the computer 8 to activate the light control relay 10,” which “switches power from the power supply 12 to the light source 4.” Gallagher, [0032], [0046]. This causes light source 4 to “illuminate[]” a “test area A,” highlighted below, that includes “a reflective surface of a marker 2.” Gallagher, [0035]-[0037], [0043], [0046]. The apparatus measures the level of reflectivity (a reflective characteristic) of the “road markers.” Gallagher, [0032]-[0033], [0066]-[0068].

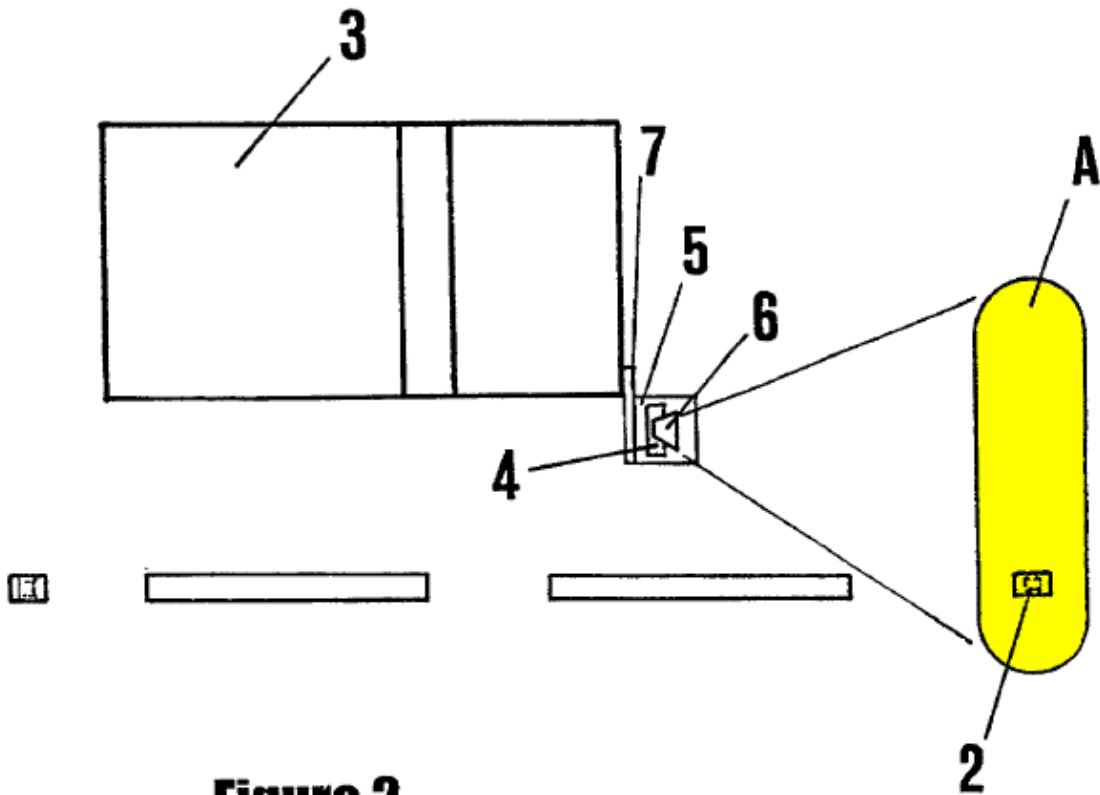


Figure 2

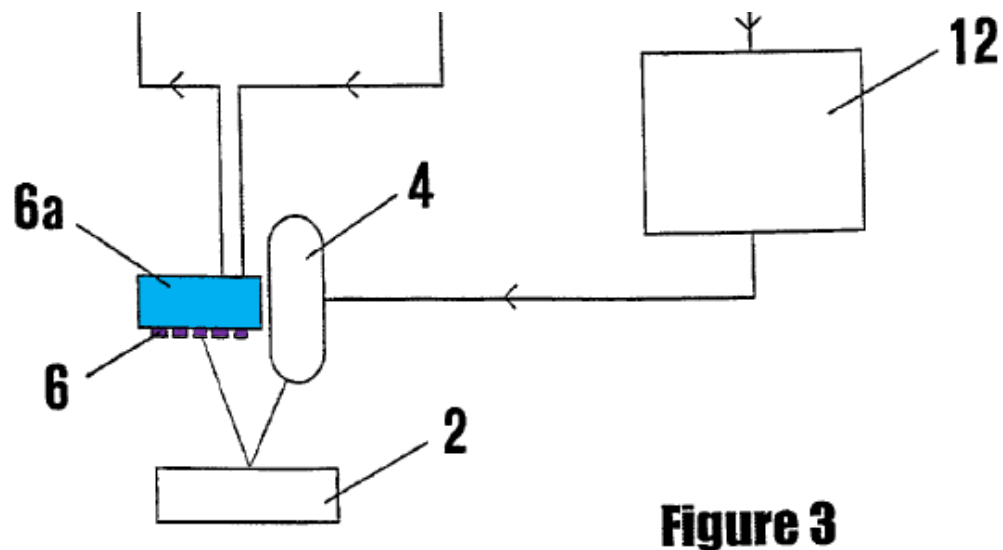
Gallagher, Fig. 2 (annotated).

- c. **[12B]: “determining a plurality of light intensity values with at least one intensity sensor directed to cover a field of view which includes at least a portion of the area illuminated by the light source; and”**

86. Gallagher discloses or suggests [12B].

87. Gallagher’s apparatus includes or at least suggests “at least one intensity sensor directed to cover a field of view which includes at least a portion of the area illuminated by the light source” because it includes a “light sensor module 6a” (intensity sensor) with an array of “light sensors 6,” one or more of which detects “reflected light” from “a reflective surface of a marker 2.” Gallagher,

[0038], [0040]-[0041], [0046]. The array of light sensors “cover[s] a wide field of view,” with each light sensor covering “a section of the area A” that is illuminated by light source 4 (a field of view which includes at least a portion of the area illuminated by the light source) and “arranged to detect reflected light from a relatively small viewing angle.” Gallagher, [0009], [0035]-[0037], [0040], [0060]. The cropped and annotated version of Figure 3, below, depicts an array of **light sensors 6** aligned in a **light sensor module 6a**. Gallagher, [0038], [0040], Fig. 3.



Gallagher, Fig. 3 (cropped, annotated).

88. A POSITA would have understood that Gallagher’s light sensor module 6a determines a plurality of light intensity values within the area A (its field of view) via its light sensors 6. For example, Gallagher discloses sampling “at frequent intervals” (e.g., 10 kHz) the data output by the light sensors in the light sensor module 6a. Gallagher, [0046]-[0047]. Gallagher uses inconsistent

terminology when referring to the data output by the light sensors. Gallagher, [0009] (“a data signal ... representing the reflectivity of each said area of road”), [0016] (“data on the reflectance levels”), [0047] (“road marking reflectance level data”), [0056] (“data ... on the reflected light”), [0060] (“data ... showing the reflectance levels”). But a POSITA would have understood from Gallagher and the data output by each light sensor corresponds to a measure of a light intensity value within the area A.

89. Gallagher discloses that its computer “get[s] the data ... on the reflected light detected by the light sensors 6”; “determine[es] the background reflectance level on the road and establish[es] non-marker reflectance levels”; selects, from the data “on the reflected light detected by the light sensors 6,” “which reflectance levels indicate a road marker” and then “determin[es] the reflectance level of the road marker in a value of millicandela per Lux (CIL).” Gallagher, [0055]-[0056], [0066]-[0067]. CIL, also known as the “coefficient of luminous intensity,” was a well-known way to express “the ratio of luminous intensity of [the] reflector in the direction of the observation to the illumination at the retroreflector on a plane perpendicular to the light.” Ex. 1012, 4 (“The International Commission of Illumination (CIE) uses the term coefficient of luminous intensity that is defined as the ratio of luminous intensity of reflector in the direction of the observation to the illumination at the retroreflector on a plane

perpendicular to the light.” Like Gallagher’s CIL value, the coefficient of luminous intensity “is expressed as candelas, cd ([equivalent to 1000 millicandelas]), per lux, lx.”). A POSITA would have understood that data output by each of the light sensors 6 is indicative of the measured luminous intensity values (a plurality of light intensity values) within the area A. See Ex. 1013, 1:18-19 (“A light sensor generates an output signal indicating the intensity of light incident upon the light sensor.”). A POSITA would have understood that the selected luminous intensity value gives Gallagher’s computer the “millicandela” (luminous intensity) portion of the determined “reflectance level of the road marker in a value of millicandela per Lux (CIL).” Gallagher, [0067].

- d. **[12C]: “using a computer processing system configured to: [12D] identify a portion of at least one light intensity value of the plurality of light intensity values associated with one of the at least one reflective surface of the road marker; and [12E] analyze the portion of the at least one light intensity value of the plurality of light intensity values to determine an assessment for the reflective characteristic of the road marker.”**

90. Gallagher discloses or suggests [12C] and its sub-elements [12D] and [12E].

91. Gallagher’s apparatus includes “a computer 8” (computer processing system) configured to perform various tasks. Gallagher, [0045], [0047], [0049]-[0070]. As discussed below, Gallagher’s computer processing system is configured

to perform each of the corresponding elements for [12D], the “identify” function, and [12E], the “analyze” function.

92. For [12D], Gallagher’s computer processing system is configured to “identify a portion of at least one light intensity value of the plurality of light intensity values associated with one of the at least one reflective surface of the road marker” because it discloses that computer 8 obtains “the data ... on the reflected light detected by the light sensors 6” (light intensity values of the plurality of light intensity values), “determin[es] the background reflectance level on the road and establish[es] non-marker reflectance levels,” and “select[s], from data obtained ..., which reflectance levels indicate” a reflective surface of a road marker (e.g., painted lines and/or raised pavement marker) (identifying a portion of the light intensity values associated with one of the at least one reflective surface of the road marker). Gallagher, [0033], [0055]-[0056], [0065]-[0066]. Gallagher discloses that “the peak responses sensed are determined as the highly reflective surfaces of a road marker.” Gallagher, [0066]. Because the reflectance level data from the light sensors indicate the light intensity values, *supra* Section IX.A.1.c ([12B]), Gallagher uses the light intensity values from the light sensors to identify a reflective surface of a road marker by distinguishing their reflectance levels from the “non-marker reflectance levels.” Gallagher, [0033], [0065]-[0066]. If the light intensity values do not indicate a reflective surface where one should be,

Gallagher's apparatus notes "the location of [the] missing road marker[]."

Gallagher, [0023].

93. For [12E], Gallagher's computer processing system is configured to "analyze the portion of the at least one light intensity value of the plurality of light intensity values to determine an assessment for the reflective characteristic of the road marker" because, after the computer 8 selects which portion of the light intensity values "indicate[s] a road marker," the computer 8 "determin[es] the reflectance level of the road marker in a value of millicandela per Lux (CIL)" and determines whether the determined reflectance level is "less than the predetermined minimum acceptable reflectance level" (an assessment for the reflective characteristic of the road marker). Gallagher, [0066]-[0068]. If so, Gallagher's computer 8 tags the road marker so that "it can later be identified and replaced as required." Gallagher, [0068].

2. Claim 13: "The automated method of claim 12, wherein activating a light source comprises synchronizing activation of a plurality of light sources to optimize light intensity reflected from the road marker."

94. Gallagher discloses or suggests the additional limitations of claim 13.

95. Gallagher discloses that "dual sets of light sources and light sensors can be mounted in opposite directions in one unit 5," which "is generally the side adjacent [to] the cent[er]line where bi[-]directional markers are operating."

Gallagher, [0074]. By activating both light sources mounted in opposite directions,

Gallagher discloses that “both faces of a marker 2 can be tested in one pass by the apparatus 1.” Gallagher, [0074]. Gallagher’s computer performs “an additional processing step ... to match the reflectance levels measured from the bi[-]directional faces of a road marker to be analy[z]ed, stored[,] and displayed.” Gallagher, [0054]-[0055], [0074].

96. A POSITA would have understood that Gallagher’s embodiment where two light sources are mounted in opposite directions to measure reflectance levels of the same road marker discloses that “activating a light source comprises synchronizing activation of a plurality of light sources to optimize light intensity reflected from the road marker.” For example, Gallagher discloses that an operator “initiates the measurement process by sending a signal via the computer 8 to activate the light control relay 10,” which “switches power from the power supply 12 to the light source 4.” Gallagher, [0046]. “The light source 4 subsequently illuminates a reflective surface of a marker 2” Gallagher, [0046]. In the two-light-source embodiment, a POSITA would have understood that initiating the measurement process would synchronize the activation of both light sources. This optimizes light intensity reflected from the road marker because Gallagher discloses that each individual light source is a “standard vehicle headlight” selected “to achieve a real life response from the markers 2,” thereby providing a realistic

representation of the light intensity that drivers perceive when driving along the roadway. Gallagher, [0035].

3. Claim 14: “The automated method of claim 12, wherein activating a light source comprises activating a single light source.”

97. Gallagher discloses or suggests the additional limitations of claim 14 because Gallagher’s “activating a light source,” *supra* Section IX.A.1.b ([12A]), comprises activating a single “light source 4 in the form of a standard vehicle headlight.” Gallagher, [0035].

4. Independent Claim 17

a. [17P]: “An automated system for assessing reflective surfaces disposed along a roadway comprising:”

98. Gallagher discloses or suggests [17P] for the reasons discussed in connection with [12P]. *Supra* Section IX.A.1.a.

b. [17A]: “a light source that is traversed along a roadway to illuminate an area that includes at least one reflective surface on a road marker, the road marker having a reflective characteristic;

99. Gallagher discloses or suggests [17A] for the reasons discussed in connection with [12A]. *Supra* Section IX.A.1.b.

- c. **[17B]: “means for determining a plurality of light intensity values directed to cover a field of view which includes at least a portion of the area illuminated by the light source; and**

100. As discussed in Section VII.A, [17B] is a means-plus-function term that should be construed as follows:

- Function: “determining a plurality of light intensity values directed to cover a field of view which includes at least a portion of the area illuminated by the light source”;
- Structure: a light sensor, or equivalents.

101. For the reasons discussed in connection with [12B], Gallagher’s light sensor array 6a discloses or suggests the requisite structure for “determining a plurality of light intensity values directed to cover a field of view which includes at least a portion of the area illuminated by the light source.” *Supra* Section IX.A.1.c.

- d. **[17C]: “a computer processing system configured to: [17D] identify a portion of at least one light intensity value of the plurality of light intensity values associated with one of the at least one reflective surface of the road marker; and [17E] analyze the portion of the at least one light intensity value of the plurality of light intensity values to determine an assessment for the reflective characteristic of the road marker.”**

102. Gallagher discloses or suggests [17C] and its sub-elements [17D] and [17E] for the reasons discussed in connection with [12C] and its sub-elements [12D] and [12E]. *Supra* Section IX.A.1.d.

5. Claim 21: “The automated system of claim 17, wherein the light source comprises a vehicle headlight lamp.”

103. Gallagher discloses or suggests the additional limitations of claim 21 because Gallagher discloses that the light source 4, *supra* Section IX.A.4.b ([17A]), is “a standard vehicle headlight.” Gallagher, [0035]-[0037].

6. Claim 23: “The automated system of claim 17, wherein the means for determining a plurality of light intensity values comprises a light sensor.”

104. Gallagher discloses or suggests “a light sensor” “for determining a plurality of light intensity values” for the reasons discussed in connection with [17B]. *Supra* Section IX.A.4.c.

B. Ground 2: Gallagher and Lumia Render Obvious Claims 13 and 15

1. Claim 13: “The automated method of claim 12, wherein activating a light source comprises synchronizing activation of a plurality of light sources to optimize light intensity reflected from the road marker.”

105. As discussed for Ground 1, claim 13, Gallagher discloses or suggests the additional limitations of claim 13. *Supra* Section IX.A.2. To the extent Patent Owner argues or the Board finds that “synchronizing activation of a plurality of light sources” requires alternating the activation of a plurality of light sources, Gallagher and Lumia render obvious the additional limitations of claim 13.

106. Gallagher’s light source is “a standard vehicle headlight,” such as a “continuous 12 V, 100 W sealed beam unit.” Gallagher, [0035]. A POSITA would

have understood that the light intensity produced by this light source is well suited for measuring reflectance of road markings at night, when ambient light is minimum, but would lack the intensity to run tests during the day with dependable accuracy. Gallagher, [0073] (“test runs can be conducted at night”); Lumia, 15-16, 22-24. A POSITA would have found it obvious to modify Gallagher’s design to optimize it for daytime measurements and would have looked to Lumia for implementation details of how to do so.

107. Lumia, similar to Gallagher, discloses a vehicle that measures “traffic sign retroreflectance,” but Lumia’s vehicle can do so “during daylight hours.” Lumia, 15. Lumia does so by activating “a xenon flash as a source of light,” which provides “a short burst of light sufficiently bright enough to overcome the sign luminance due to ambient daylight illumination.” Lumia, 15. Lumia discloses that such a high-intensity light source is necessary for daytime measurements because “the light source must provide an adequate amount of additional exposure above the ambient signal so that the retroreflection due to the illumination system may be appropriately detected and isolated.” Lumia, 23.

108. A POSITA would have been motivated to implement multiple xenon flashes as a source of light and synchronize their activation to optimize the reflected light intensity for daytime hours based on the teachings of Gallagher and Lumia. A POSITA would have been motivated to implement Lumia’s xenon flash

as the light source because Lumia discloses that it provides sufficient light intensity to overcome “ambient daylight illumination.” Lumia, 15. Measuring retroreflectivity during the day would have been advantageous to allow greater flexibility in testing schedules and the replacement of any markers determined to be faulty as quickly as possible to improve the safety of the roadway. Gallagher, [0003] (disclosing “being restricted to night-time testing” as a disadvantage), [0073] (disclosing testing at night and replacing “during the day”).

109. A POSITA would have been motivated to implement a plurality of Lumia’s xenon flashes and synchronize their activation to provide sufficient samples for Gallagher’s computer to accurately calculate reflectance levels. Gallagher, [0019], [0047], [0056]-[0057]. Gallagher discloses preferably “filtering the data” collected by the light sensors “by calculating an average reflectance level from a set of sampled data” “to smooth out fluctuations caused by mechanical vibrations, road imperfections, electrical interference[,] and noise and the like.” Gallagher, [0019], [0056]-[0057]. To accomplish this, Gallagher discloses “sampling road marking reflectance level data at frequent intervals.” Gallagher, [0047].

110. To ensure multiple samples at a sufficient frequency for Gallagher’s “average reflectance level from a set of sampled data,” a POSITA would have been motivated to provide multiple xenon flashes and synchronize their activation

because Lumia estimates that the flash duration for each flash should be, for example, 0.1 msec, and xenon flashes were known to have a recharge time in between flashes. Lumia, 23-24. A POSITA would have recognized that providing multiple xenon flashes would allow synchronizing their activation to increase the number of measurement samples and would have been motivated to do so because Gallagher discloses that increasing the number of samples desirably helps “smooth out fluctuations.” Gallagher, [0019], [0057].

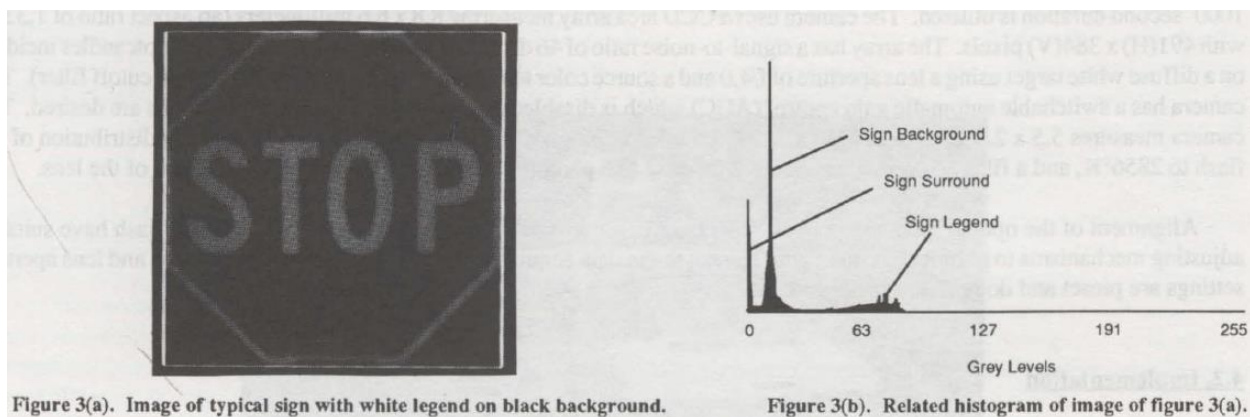
111. A POSITA would have reasonably expected success in such a design, as synchronizing the activation of multiple light sources to detect reflected light from a retroreflector was a well-known concept. International Patent Application Publication No. WO 96/17258 (“Popovich”; Ex. 1010), 12-13 (disclosing the “sequential” activation of multiple “light emitting elements” “one after another” to illuminate retroreflective objects). Moreover, Gallagher discloses that “a wide variety of light sources can be suitable” for its testing, leading a POSITA to believe that Lumia’s xenon flash would work as a light source. Gallagher, [0037]. Gallagher also discloses that, even with “three sets of light sources and sensors,” its “computer 8 is capable of simultaneously processing data obtained by the light sensors,” leading a POSITA to believe that Gallagher’s computer could support the synchronization of multiple light sources. Gallagher, [0075].

112. Accordingly, combining Gallagher and Lumia to activate the synchronizing of multiple xenon light flashes to optimize the reflected light intensities for daytime measurements would have required a POSITA to apply only conventional techniques for timing the activation of each light source and the sampling of data to measure the reflected light after each activation, which was well known at the time. Lumia, 15 (disclosing using “an electronic flash source to provide a short burst of light” and “a video camera to record the sign,” whose signal “is then converted to a digitally sampled representation of the sign”). And a POSITA would have understood that positioning each xenon flash to maintain essentially the same distance between the light source and Gallagher’s light sensor array 6a would allow each measurement to maintain essentially the same observation angle, further providing a POSITA with the reasonable expectation that such a design could successfully provide Gallagher’s computer with a useful “set of sampled data” for averaging the reflectance levels. Gallagher, [0019], [0056]-[0057].

2. Claim 15: “The automated method of claim 12, further comprising determining a luminance value utilizing the plurality of light intensity values and a characterization profile of the at least one light intensity sensor.”

113. Gallagher and Lumia render obvious the additional limitations of claim 15.

114. Lumia discloses “determining a luminance value utilizing the plurality of light intensity values and a characterization profile of the at least one light intensity sensor” because it discloses that using “a video camera” as a light sensor “effectively divides the [field of view (FOV)] defined by the system magnification into smaller FOV’s, thereby creating individual luminance meters at each sensing element site.” Lumia, 16. When the system is “properly calibrated,” the average intensity value of each area in the FOV of similar intensity “corresponds to the average luminance.” Lumia, 16. For example, Lumia discloses producing a histogram of “the retroreflected intensity distribution” in gray levels (below right) of “an actual sign” extracted using software (below left). Lumia, 15-17. This histogram can be used to identify and average legend and background values, which “correspond[] to the average luminance” of the legend and background, respectively. Lumia, 15-17.



Lumia, Figs. 3(a)-3(b).

115. Because Lumia discloses that an intensity value determined from the image captured by the video camera corresponds to a luminance value when properly calibrated, a POSITA would have understood Lumia's calibration to disclose a characterization profile that relates the light intensity values of the video camera (light intensity sensor) to corresponding luminance values. Because retroreflectance can be calculated by dividing "the luminance of the reflected light" by "the normal illumination incident on the retroreflector," determining the luminance and knowing the illumination allows the retroreflectance to "be readily obtained." Lumia, 15-16.

116. A POSITA would have found it obvious to implement Lumia's determining a luminance value utilizing the plurality of light intensity values and a characterization profile of the at least one light intensity sensor to allow Gallagher's apparatus to calculate the retroreflectivity of road markers. A POSITA would have been motivated to do so because, as was well known at the time, several road authorities specified minimum retroreflectivity values for road markings along a roadway. *E.g.*, McGee, 6, 8-11. Because Gallagher recognizes that "road[] authorities worldwide invariably advocate different standards for road markings" and expressed a desire to analyze the data "in a way and to an extent that meets the criteria of each country," a POSITA would have been motivated to implement Lumia's determining a luminance value to allow its apparatus to

identify and tag any markers “that do not meet the predetermined minimum acceptable reflectance level” for countries that require a minimum retroreflectivity level for road markers. Gallagher, [0049], [0077].

117. A POSITA would have had a reasonable expectation of success because both Gallagher and Lumia relate to apparatuses that measure reflective characteristics of retroreflective surfaces from a moving vehicle using a light intensity sensor, giving a POSITA the expectation that Lumia’s determining a luminance value could be readily implemented in Gallagher’s apparatus. Gallagher, [0031]-[0039]; Lumia, 15-17. Additionally, Gallagher discloses that “[a] variety of light sensors are envisaged as being suitable in the apparatus 1,” further giving a POSITA the expectation that a light sensor could be selected and calibrated to associate the light intensity value to a corresponding luminance value. Gallagher, [0037], [0039]. Indeed, similar to Lumia’s “properly calibrated” light sensor array, Gallagher discloses determining “calibration factors for each individual sensor in the array” based on “static tests in a laboratory,” meaning a POSITA would have had to apply only conventional techniques to similarly provide Gallagher’s light sensor array with a characterization profile based on calibration factors that relate each measured light intensity value to a luminance value. Lumia, 16; Gallagher, [0058]-[0059].

C. Ground 3: Gallagher and Schofield Render Obvious Claims 18-19

- 1. Claim 18: “The automated system of claim 17, wherein the computer processing system further comprises a color identification subsystem, the color identification subsystem configured to associate at least one color with the reflective characteristic of the road marker.”**

118. Gallagher and Schofield render obvious the additional limitations of claim 18.

119. Gallagher discloses one embodiment where the light sensors in the light sensor module are “photodiodes mounted precisely ... at a height and angle to properly detect reflected light.” Gallagher, [0039]. But Gallagher also discloses that “[a] variety of light sensors” are “suitable” in its apparatus. Gallagher, [0039]. In particular, when “sensing [colored] markers, light sensors with different spectral responses or similar light sensors with different filters can be used” such that “[t]he data signals detected by the sensors ... indicate the [color] of a road marking being tested.” Gallagher, [0039]. When using Gallagher’s reflectivity measuring apparatus “to test different [colored] road markings simultaneously,” a POSITA would have found it obvious to implement Schofield’s use of color to associate at least one color (e.g., yellow, red, and/or white) with the reflective characteristic of the road marker (e.g., its reflectance levels) to confirm the assessment as to whether the road marker’s reflective characteristic meets the predetermined minimum reflectance levels. Gallagher, [0039].

120. Schofield discloses using color to assist in identifying objects of interest because it discloses identifying the “spectral signature” of a light source—its color—to “warn the driver that a light has changed from green to yellow to red,” to identify “red octagons ... as stop signs,” or to identify “yellow triangles as caution signs,” for example. Schofield, 11:60-64, 12:1-4. Schofield also teaches that “[l]ane markers ... may be readily identified by spectral signature.” Schofield, 10:43-45.

121. A POSITA would have been motivated to implement Schofield’s use of color to confirm the color of the measured road marker because Gallagher suggests such a combination, as Gallagher discloses using its reflectivity measuring apparatus to sense “[colored] markers” and “to test different [colored] road markings simultaneously.” Gallagher, [0039]. This would have suggested to a POSITA to use Schofield’s identification of objects of interest using spectral signature to assist in assessing the type of road marker with which an identified reflective surface is associated.

122. Road markers were well known to be a variety of colors, including yellow, white, and red, each of which indicates different information to the driver. American Society for Testing and Materials D4383–96, Standard Specification for Plowable, Raised Retroreflective Pavement Markers (July 1996) (“ASTM”; Ex. 1008), 451-453 (disclosing white, yellow, red, blue, and green raised

retroreflective pavement markers); Pezoldt, 29-30, 55 (disclosing “retroreflective raised pavement marker products” “in a variety of reflective colors and color combinations,” including yellow, white, and red). As was known, each color of road marker required a different reflectance level. Pezoldt, 29-30. A POSITA would have been motivated to associate at least yellow, white, or red with the reflective characteristic (e.g., its reflectance level) of the road marker to confirm the assessment of whether the reflective characteristic satisfied the “minimum acceptable reflectance level” for the particular color of road marker. Gallagher, [0068].

123. A POSITA would have had a reasonable expectation of success because Schofield teaches different techniques for associating yellow, white, and red with other characteristics of a particular object of interest (e.g., associating pairs of white light sources with oncoming headlights, yellow triangles with caution signs, and red octagons with stop signs) that a POSITA would have reasonably expected to work with Gallagher’s array of “light sensors with different spectral responses or similar light sensors with different filters.” Schofield, 10:35-50, 11:1-6, 12:1-8; Gallagher, [0039]. Schofield also discloses that “reflectivity” and “spectral characteristics” may be used together to identify objects of interest. Schofield, 11:1-3. Accordingly, combining Gallagher and Schofield to associate yellow, white, or red with a reflective characteristic of the road marker to confirm

the assessment of whether the reflective characteristic satisfied the minimum acceptable reflectance level for the particular color of road marker would have required a POSITA to apply only conventional techniques of associating a color with reflectivity to yield the predictable result of confirming the assessment of the reflective surface.

2. Claim 19: “The automated system of claim 18, wherein the at least one color is selected from a set of colors consisting of yellow, green, red and white.”

124. As discussed in connection with claim 18, Gallagher and Schofield render obvious associating at least yellow, red, and white with the reflective characteristic of the road marker, so Gallagher and Schofield render obvious the additional limitations of claim 19. *Supra* Section IX.C.1.

D. Ground 4: Gallagher and Frank Render Obvious Claim 20

1. Claim 20: “The automated system of claim 17, wherein the light source comprises a laser scanning device.”

125. Gallagher and Frank render obvious the additional limitation of claim 20.

126. Frank, similar to Gallagher, discloses an apparatus that “may be mounted in any location on the vehicle where the apparatus can be provided with a view of at least one retroreflector ahead of the vehicle” and identifies the retroreflectors along a roadway. Frank, 4:10-51, 6:4-11. Frank discloses a light source that comprises a laser scanning device because its apparatus is a “laser radar

apparatus” that includes a laser diode 332, whose light beam 336 passes through a lens “to produce [a] fan beam 339” that is “reflected from mirror surface 330 and is directed towards roadway 102.” Frank, 1:13-29, 4:52-5:9. The mirror surface 330 “is controlled by servo motor 333” that “oscillates through a particular range of motion at a particular frequency to produce a regular scanning motion of fan beam 339” over “a particular area.” Frank, 4:52-5:17.

127. Frank’s apparatus also includes an optical receiver that receives the reflected light back from the retroreflectors. Frank, 7:27-31, 10:61-67. A distance from the light source to the retroreflector can be determined “by measuring a phase difference between transmitted and received carrier waves modulated on the light beam” or by measuring “[t]he time delay between the transmitted and received pulses.” Frank, 7:34-42, 10:61-67. An angle of the reflected light relative to the vehicle’s heading “can be determined from the position on the array in which the signal is received.” Frank, 7:47-50, 10:67-11:4. Frank’s optical receiver is a “photodiode array” or any “other type of photosensitive array.” Frank, 10:67-11:4, 13:64-14:15.

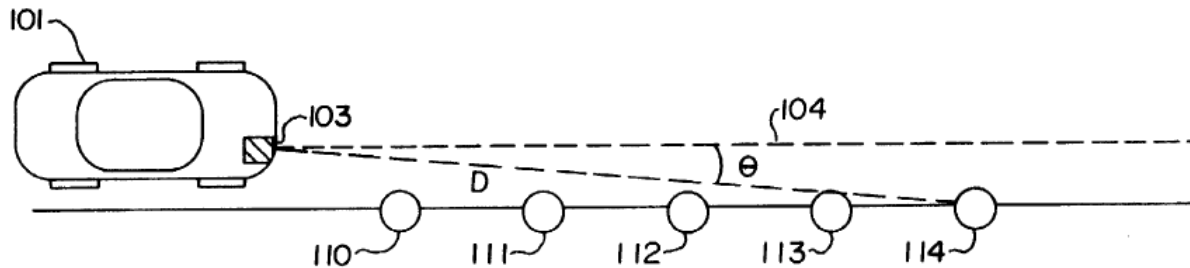


FIG. 2

Frank, Fig. 2.

128. A POSITA would have found it obvious to implement Frank's laser scanning device as Gallagher's light source 4 to improve the accuracy of Gallagher's reflectivity measurements by obtaining improved estimates of the distance and angle to the retroreflector. A POSITA would have been motivated to do so because providing Gallagher's apparatus with a light source like Frank's laser scanning device would have allowed Gallagher's computer to determine the precise distance from the light source to each road marker, which would have improved Gallagher's determination of "the reflectance level of the road marker in a value of millicandela per Lux" by allowing Gallagher's computer processing system to factor in a precise distance to the road marker for each measurement in its determination. Gallagher, [0067]-[0068].

129. A POSITA would have reasonably expected success in such a combination because Gallagher discloses that "a wide variety of light sources can

be suitable” for its testing, leading a POSITA to expect success implementing Frank’s light source. Gallagher, [0037]. Additionally, Frank discloses that its determination can be carried out using a “photodiode array,” like the one disclosed in Gallagher, or any “other type of photosensitive array,” like Schofield’s array. Frank, 10:67-11:4, 13:64-14:15. Accordingly, a POSITA would have only needed to apply conventional data processing techniques to implement Frank’s laser scanning device and obtain accurate distance measurements from the light source to each retroreflector using Gallagher’s light sensor apparatus, for example, by “measuring a phase difference between transmitted and received carrier waves modulated on the light beam.” Frank, 7:27-42.

E. Ground 5: Gallagher and Currie Render Obvious Claim 22

- 1. Claim 22: “The automated system of claim 21, wherein the vehicle headlight lamp is selected from a group consisting of a light emitting diode, a xenon lamp, a halogen lamp, a fluorescent lamp, and an incandescent lamp.”**

130. Gallagher and Currie render obvious the additional limitations of claim 22.

131. As discussed in connection with claim 21, Gallagher discloses that the light source 4 is “a standard vehicle headlight.” Gallagher, [0035]-[0037]; *supra* Section IX.A.5.

132. A POSITA would have found it obvious to use an incandescent lamp for the “standard vehicle headlight.” Gallagher, [0035]. Gallagher does not provide

any examples of a standard vehicle headlight, but a POSITA would have known that incandescent lamps were ubiquitous as vehicle headlights at the time.

Ex. 1020, 7:14-18 (disclosing “a tungsten incandescent lamp” as an example of “an automotive headlamp”); Gallagher, [0035]. A POSITA would have been motivated to use an incandescent lamp for the standard vehicle headlight because Currie discloses that, compared to other light sources, an incandescent light source provides “enhanced reflection intensity” from the same type of road markers that Gallagher desires to measure, suggesting to a POSITA that an incandescent lamp would have been a suitable type of vehicle headlight for use in Gallagher’s apparatus. Currie, 4:31-42.

133. A POSITA would have had a reasonable expectation of success because Currie discloses that incandescent light sources are suitable light sources for illuminating retroreflectors along a roadway, leading a POSITA to expect success in implementing Gallagher’s standard vehicle headlight as an incandescent lamp. Currie, 4:31-42. Moreover, incandescent lamps were well-known types of standard vehicle headlights, and Gallagher discloses that standard vehicle headlights, as well as “a wide variety of light sources,” are suitable for use in its apparatus. Gallagher, [0035]-[0037].

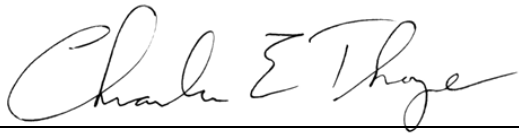
* * *

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

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

136. I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on this 19th day of July 2024.

By: 
Charles E. Thorpe