

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MOBILEYE GLOBAL, INC.,

Petitioner,

v.

MANDLI COMMUNICATIONS, INC.,

Patent Owner.

Case IPR2024-01111

Patent No. 9,671,328

PETITION FOR *INTER PARTES* REVIEW

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PETITIONER’S EXHIBIT LIST

Exhibit	Description
Ex. 1001	U.S. Patent No. 9,671,328 (“the ’328 patent”)
Ex. 1002	Prosecution History of the ’328 patent
Ex. 1003	Declaration of Charles E. Thorpe, Ph.D. (“Thorpe”)
Ex. 1004	Curriculum Vitae of Charles E. Thorpe, Ph.D.
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. 1009	U.S. Patent No. 5,313,262 to Leonard (“Leonard”)
Ex. 1010	International Publication No. WO 96/17258 to Popovich (“Popovich”)
Ex. 1011	U.S. Patent No. 9,335,255 (“the ’255 patent”)
Ex. 1012	K.L. Black et al., <i>NCHRP Report No. 346: Implementation Strategies for Sign Retroreflectivity Standards</i> , Transportation Research Board (April 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 Vision V, Donald J. Svetkoff, Editor, Proc. SPIE 1385, pp. 15-26 (1991) (“Lumia”)

Exhibit	Description
Ex. 1015	Kenneth D. Uding, <i>Exact Road Geometry Output Program for Retroreflective Road Sign Performance</i> , Transportation Research Record 1421 (1993) (“Uding”)
Ex. 1016	V.J. Pezoldt et al., <i>Raised Pavement Marker Reflectivity</i> , Report No. TX-90/1151-1F, Texas Transportation Institute (Nov. 1990) (“Pezoldt”)
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”)
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Ex. 1021	Declaration of Raymond Cruitt
Ex. 1022	Declaration of Kelley M. Hayes Greenhill

I. PRELIMINARY STATEMENT

Mobileye Global, Inc. (“Petitioner”) requests review under 35 U.S.C. § 311 and cancellation of claims 1-22 of U.S. Patent No. 9,671,328 (“the ’328 patent”) based on the grounds set forth in Section II. The ’328 patent was filed about fifteen years after its priority claim and claims substantially different subject matter than was originally claimed. In the end, all that remains are claims that combine conventional elements for measuring reflectivity and detecting objects using known object-detection techniques. As shown in the grounds below, nothing in the claims recites anything novel or nonobvious. Therefore, this IPR should be instituted and the claims canceled.

II. PRECISE RELIEF REQUESTED

Prior Art:

Exhibit / Name	Number / Title	Effective Filing Date	Issue / Publication Date	Prior-Art Provision
1005 “Gallagher”	U.S. Patent Application Publication No. 2002/0063638	Mar. 5, 1998	May 30, 2002	AIA: 102(a)(2) Pre-AIA: 102(e)
1006 “Schofield”	U.S. Patent No. 5,796,094	Mar. 25, 1996	Aug. 18, 1998	AIA: 102(a)(1)-(2) Pre-AIA: 102(a)-(b), (e)

1007 “Frank”	U.S. Patent No. 5,202,742	Oct. 3, 1990	Apr. 13, 1993	AIA: 102(a)(1)-(2) Pre-AIA: 102(a)-(b), (e)
1008 “ASTM”	American Society for Testing and Materials D 4383–96, Standard Specification for Plowable, Raised Retroreflective Pavement Markers		July 1996	AIA: 102(a)(1) Pre-AIA: 102(a)-(b)
1009 “Leonard”	U.S. Patent No. 5,313,262	Sept. 30, 1992	May 17, 1994	AIA: 102(a)(1)-(2) Pre-AIA: 102(a)-(b), (e)
1010 “Popovich”	International Publication No. WO 96/17258	Nov. 30, 1995	June 6, 1996	AIA: 102(a)(1) Pre-AIA: 102(a)-(b)

Unpatentability Grounds:

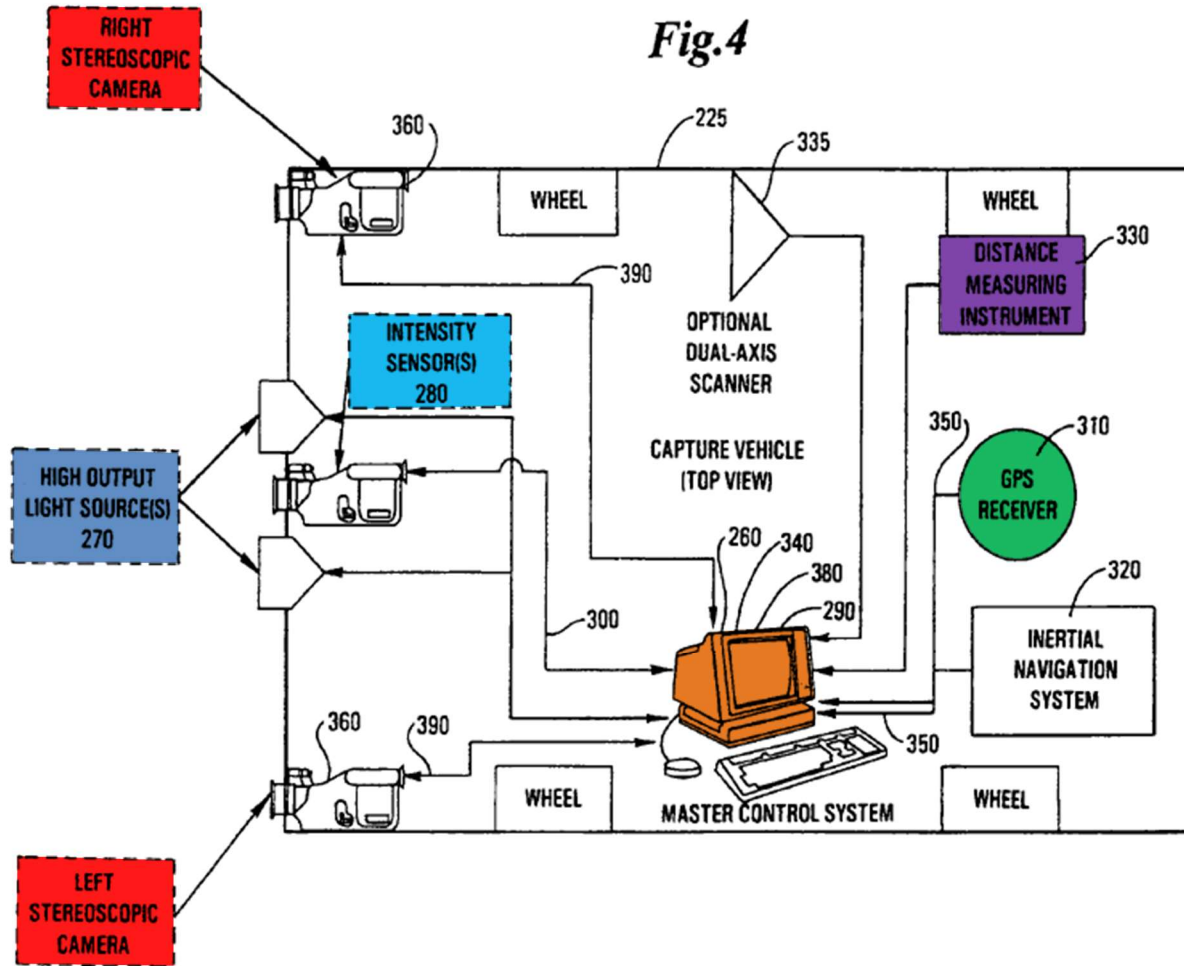
1	Gallagher and Schofield render obvious claims 1-4, 8-13, and 17-18
2	Gallagher, Schofield, and Frank render obvious claims 15-16, 19, and 21-22
3	Gallagher, Schofield, Frank, and ASTM render obvious claims 14 and 20
4	Gallagher, Schofield, Leonard, and Popovich render obvious claims 5-7

III. THE '328 PATENT

A. Specification

The '328 patent discloses a system for determining reflective objects of interest along a roadway. Ex. 1001, Abstract; Thorpe ¶¶41-48. The '328 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, 1:39-46. It states that those inaccuracies are due to “wide variations in lighting and conditions.” *Id.*, 1:46-47.

Like the prior art, the '328 patent's system determines “retroreflectivity values for reflective surfaces disposed along a roadway” using “subsystems located on/in a capture vehicle 225.” *Id.*, 3:66-4:4, 7:65-8:18. (Retroreflectivity is the ability of an object to reflect light back to its source. Ex. 1014, 15-16.) 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, 10:18-21 (emphasis added).



Id., Fig. 4 (annotated).

A distance measuring instrument 330 and GPS receiver 310 form part of a vehicle positioning system 240 (shown in Figure 3) that generates position measurements (e.g., position of the vehicle and distance from the vehicle to a road marker). *Id.*, 8:9-14, 10:21-27, Fig. 3. Stereoscopic cameras 360 constitute a digital imagery system 390 used in “the creation of objects of interest 460 and their associated attributes 465.” *Id.*, 10:35-38.

“The **high output light source(s) 270** and **light intensity sensor(s) 280** constitute the light intensity measurement system 230.” *Id.*, 8:3-6, 10:28-30. Light intensity measurement system 230 (shown in Figure 3) generates intensity measurements “in response to the repeated strobing of the **high output light source 270**,” allowing the collection of data for computing retroreflectivity. *Id.*, 8:6-9, 10:30-34. The number of intensity values in each intensity measurement can correspond to “the number of pixels in the light intensity sensor’s 280 array.” *Id.*, 11:39-45.

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. *Id.*, 8:14-56, 9:12-10:17, Fig. 3.

The ’328 patent discloses that intensity is “determined from the gray value of the corresponding pixels” in the image of the light intensity sensor 280. *Id.*, 11:36-39. “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.” *Id.*, 11:55-60. With a “uniform light source,” knowing the luminance and the distance to the object of interest allows the retroreflectivity to be approximated. *Id.*, 12:7-22.

The '328 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.” *Id.*, 9:1-11. Through incorporation by reference of its parent application, the '328 patent discloses that “pavement markings” include reflective surfaces whose retroreflectivity may be measured. *Id.*, 1:7-27; Ex. 1011, 17:26-18:30; *see* Ex. 1001, 17:54-56 (reciting that “the road marker is an object of interest selected from the set consisting of a road sign or a pavement marker”).

Notably, none of the '328 patent's techniques for determining reflectivity laid out in its “Summary of the Invention” are recited in the claims.

B. Level of Ordinary Skill in the Art

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. Thorpe ¶31. Higher levels of education may offset less experience and extensive experience can substitute for formal education. Thorpe ¶31.

C. Claim Construction

No terms need to be construed under 37 C.F.R. § 42.100(b) to resolve unpatentability. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) (“[O]nly those [claim] terms need be construed that are in

controversy, and only to the extent necessary to resolve the controversy.”). The plain meaning of each term should apply for the purpose of this IPR.¹

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1: Gallagher and Schofield Render Obvious Claims 1-4, 8-13, and 17-18

1. Gallagher

Gallagher, like the '328 patent, discloses a “reflectivity measuring apparatus” used on a moving vehicle. Gallagher, [0001], [0031]-[0033]; Thorpe ¶¶52-55. Gallagher discloses that “[l]ight reflective road markings and markers” “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].

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

¹ Petitioner reserves the right to argue that certain limitations in the challenged claims are indefinite and/or require construction to resolve controversies in other forums.

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 closely mounted “to reduce the observation angle to almost zero.” Gallagher, [0041]. Figure 1, below, depicts this apparatus.

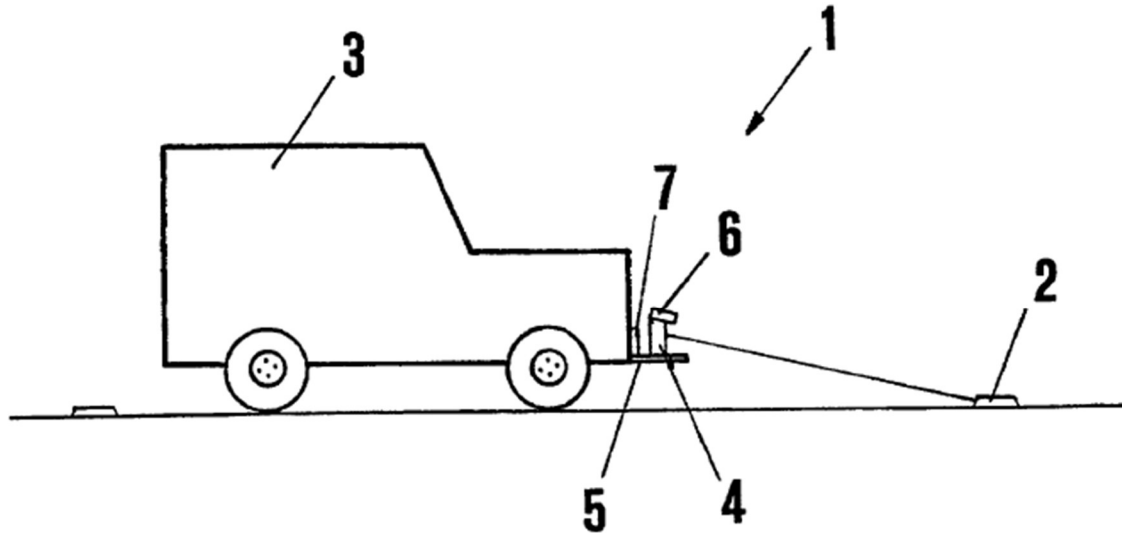


Figure 1

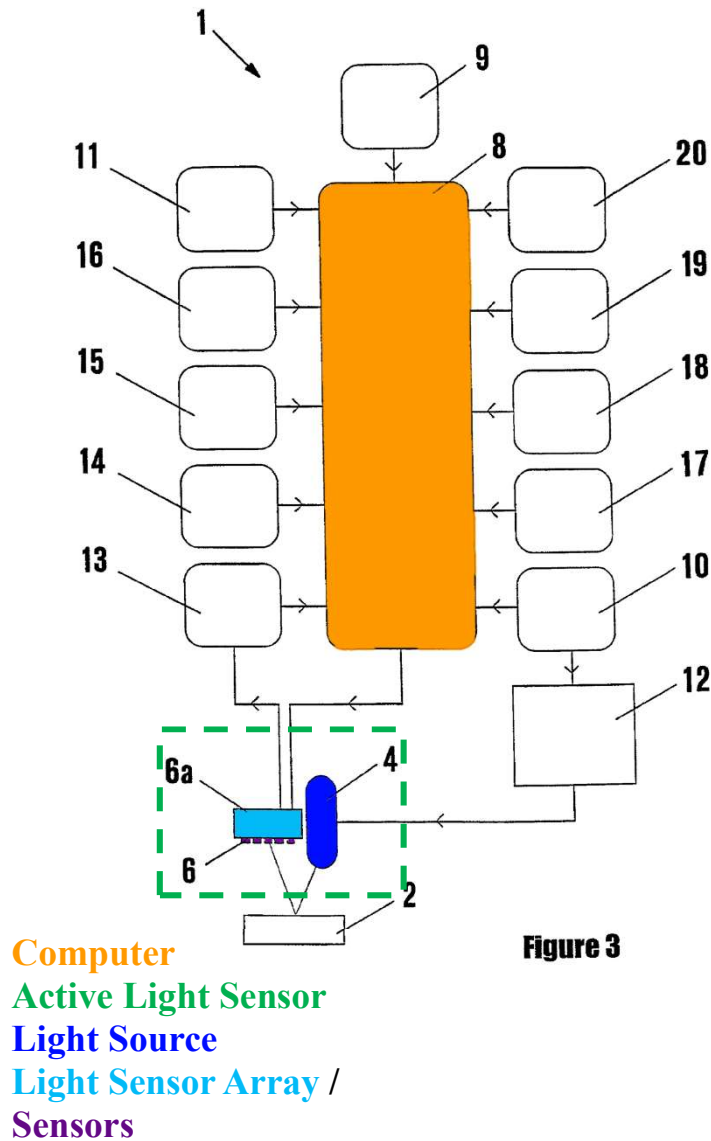
Gallagher, Fig. 1.

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]. Gallagher’s apparatus also provides “an audio and/or visual indicator” of the vehicle’s position on the road 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].

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



Gallagher, Fig. 3 (annotated).

2. Schofield

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; Thorpe ¶¶56-59. Light sources include

“[l]ane markers, signs, and other sources of reflected light.” Schofield, 10:43-45.

Schofield’s system can “identify particular traffic signs” and “detect lane markers,” among other light sources. Schofield, 12:1-4, 12:40-42.

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.

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.

Schofield’s system identifies “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, it can “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.

3. Gallagher and Schofield Are Analogous Art

Gallagher and Schofield are analogous art to the ’328 patent because they are in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:31-32; Gallagher, [0007], [0066], [0078]; Schofield, 1:56-2:15, 9:24-26;

Thorpe ¶60. Gallagher and Schofield are also analogous art to the '328 patent because they are reasonably pertinent to problems addressed by the '328 patent, including automatically identifying road markers without relying solely on “template matching of shape and color.” Ex. 1001, 1:39-47; Gallagher, [0066] (identifying road markers based on “peak responses sensed” by light sensors); Schofield, 10:66-11:12 (using various characteristics, including “reflectivity,” for object identification); Thorpe ¶60.

4. Independent Claim 9

a. [9P]: “An automated system for assessing reflective surfaces disposed along a roadway comprising:”

If limiting, Gallagher discloses [9P]. Thorpe ¶¶61-62.

Gallagher discloses an automated system for assessing reflective surfaces disposed along a roadway using its reflectivity measuring apparatus. Gallagher, [0033]-[0035]; Thorpe ¶62. Gallagher’s 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 the reflected-light data and selects “which reflectance levels indicate a road marker.” Gallagher, [0046], [0055]-[0066]; Thorpe ¶62. 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 the computer automatically measures reflectivity “in real time.” Gallagher, [0046], [0071]; Thorpe ¶62.

- b. [9A]: “an active light sensor that is traversed along a roadway that includes at least one reflective surface on a road marker, the road marker having a reflective characteristic, the active light sensor including: [9B] a light source to illuminate an area that includes the at least one reflective surface; and [9C] a light sensor that measures a plurality of light intensity values within a field of view which includes at least a portion of the area illuminated by the light source; and”**

Gallagher discloses or suggests [9A] and its sub-elements [9B] and [9C].

Thorpe ¶¶63-69.

Gallagher’s apparatus includes an active light sensor including “a light source 4” and an array of light sensors 6 “aligned in an encased module 6a.”

Gallagher, [0035]-[0039]; Thorpe ¶64. As discussed below, Gallagher’s active light sensor includes the corresponding claim elements for [9B], the light source, and [9C], the light sensor. Thorpe ¶64.

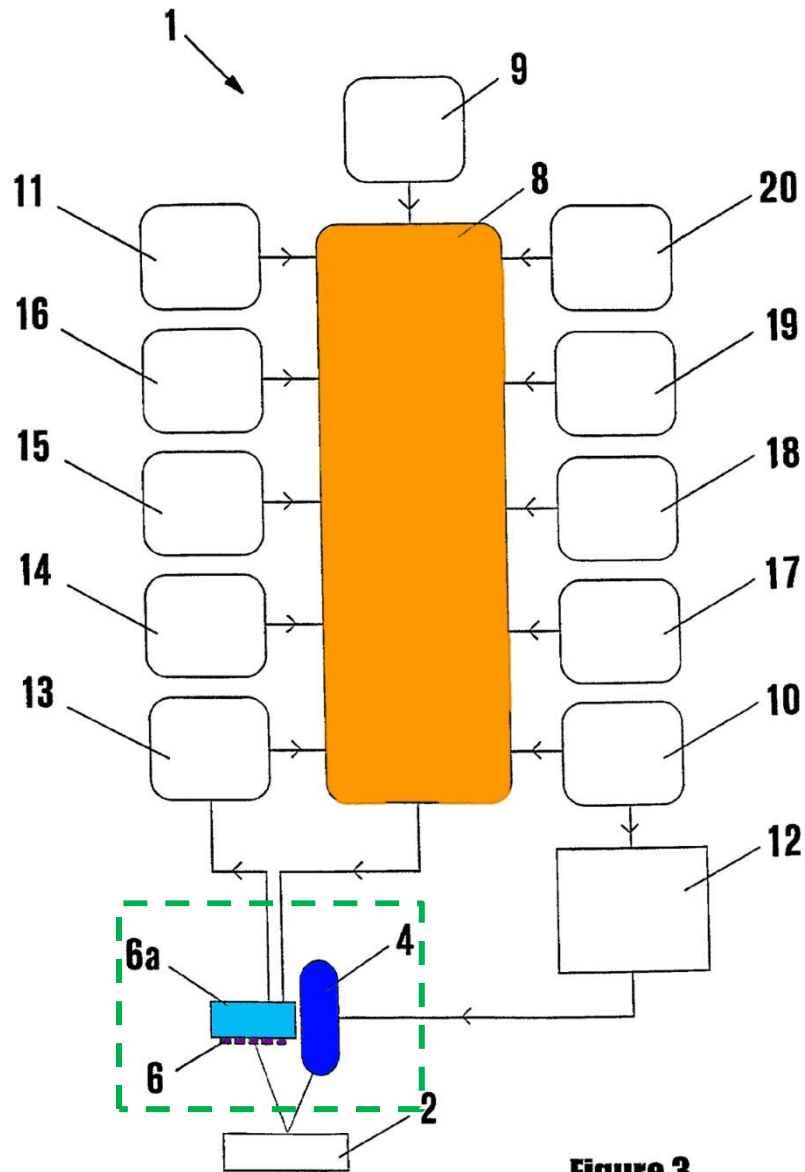


Figure 3

Computer

Active Light Sensor

Light Source

Light Sensor Array / Sensors

Gallagher, Fig. 3 (annotated).

Gallagher’s active light sensor is traversed along a roadway because it measures reflectivity from a vehicle traveling “at speeds of up to about 100 kph”

(traverses) “on a road” (along a roadway). Gallagher, [0031]-[0032], Fig. 2 (below); Thorpe ¶65. The roadway includes raised pavement markings that “have two highly reflective surfaces” (at least one reflective surface on a road marker). Gallagher, [0005], [0034]; Thorpe ¶65. The apparatus measures the road marker’s reflectivity level (a reflective characteristic). Gallagher, [0032]-[0033], [0066]-[0068].

For [9B], Gallagher’s active light sensor includes “a light source to illuminate an area that includes the at least one reflective surface” because it discloses “a light source 4 in the form of a standard vehicle headlight” that, when activated, “illuminates” a “test area A” along the roadway that includes “a reflective surface of a marker 2.” Gallagher, [0035]-[0037], [0043], [0046]. For example, a wide-beam light source illuminates an area along the roadway in front of the vehicle, as highlighted below, with the area A including at least one reflective surface on marker 2. Gallagher, [0035], Fig. 2; Thorpe ¶66.

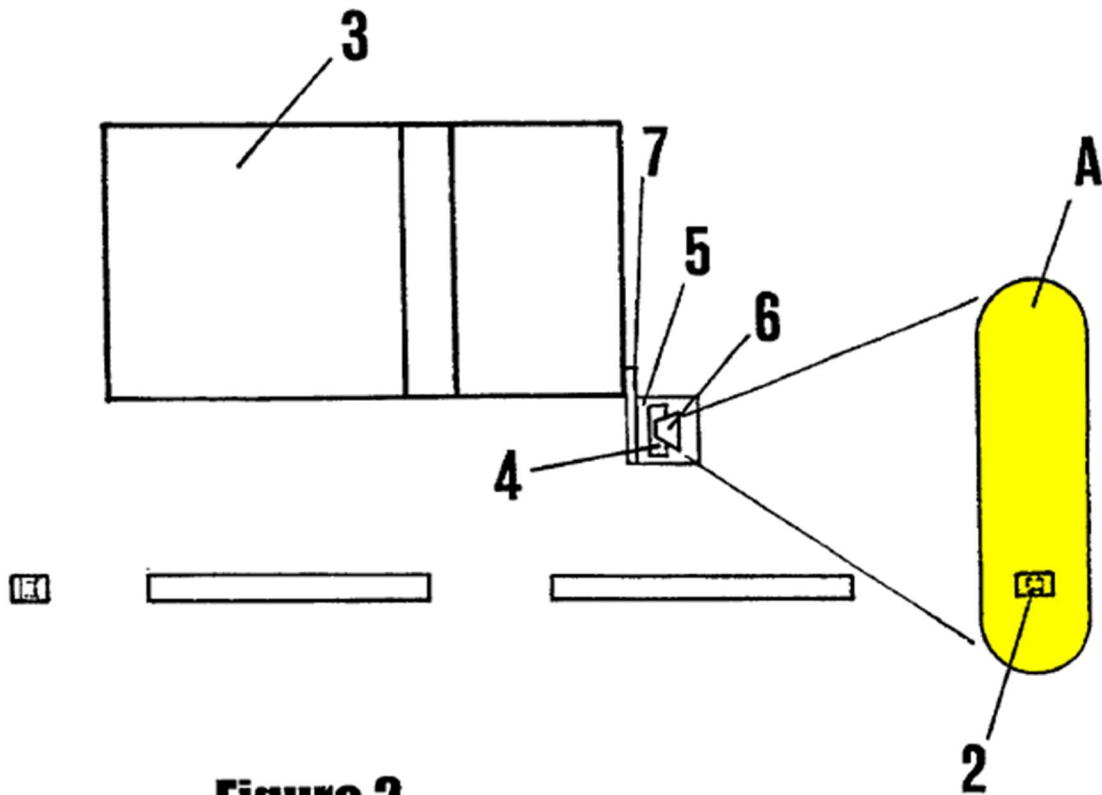
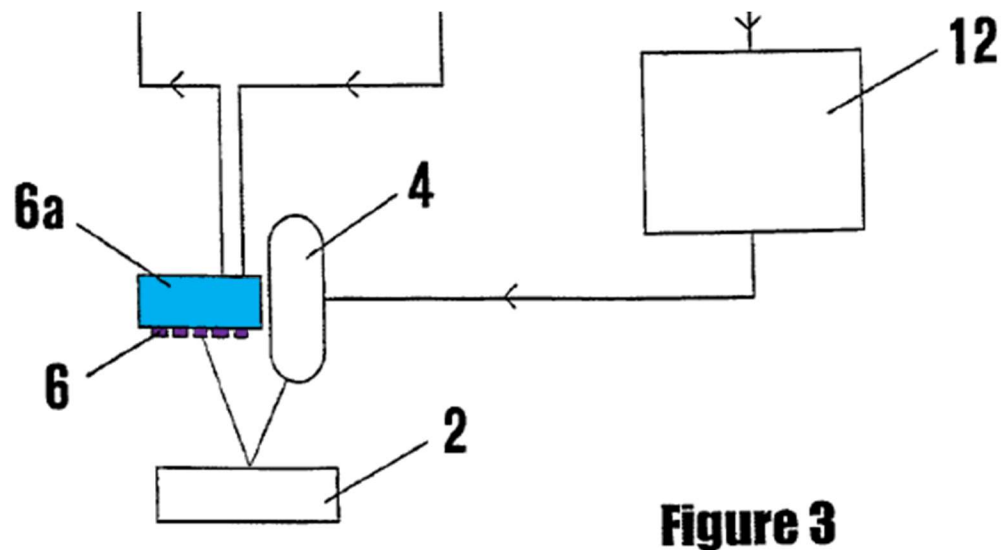


Figure 2

Gallagher, Fig. 2 (annotated).

For [9C], Gallagher's active light sensor also includes or at least suggests "a light sensor that measures a plurality of light intensity values within 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" (light 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]; Thorpe ¶67. The array "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], [0040], [0060], Fig. 2; Thorpe ¶67. 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; Thorpe ¶67.



Gallagher, Fig. 3 (cropped, annotated).

A POSITA would have understood that Gallagher’s light sensor module 6a measures a plurality of light intensity values within the area A (its field of view) via its light sensors 6. Thorpe ¶68. For example, Gallagher discloses that its computer 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; Thorpe ¶69. 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. Thorpe ¶69; *see* Ex. 1013, 1:18-19 (“A light sensor generates an output signal indicating the intensity of light incident upon the light sensor.”).

- c. **[9D]: “a computer processing system operably connected to the active light sensor and configured to detect objects of interest within the field of view and for each object of interest:”**

Gallagher discloses [9D]. Thorpe ¶¶70-72.

Gallagher’s apparatus includes “a computer 8” (computer processing system) that “get[s] the data ... on the reflected light detected by the light sensors 6” (operably connected to the active light sensor). Gallagher, [0033], [0045], [0047], [0055]-[0066]; Thorpe ¶71. These light sensors provide computer 8 with light intensity values from the area A (field of view). *Supra* Section IV.A.4.b ([9C]); Thorpe ¶71. As shown in the figure below, the computer 8 is operatively connected to the active light sensor. Thorpe ¶71.

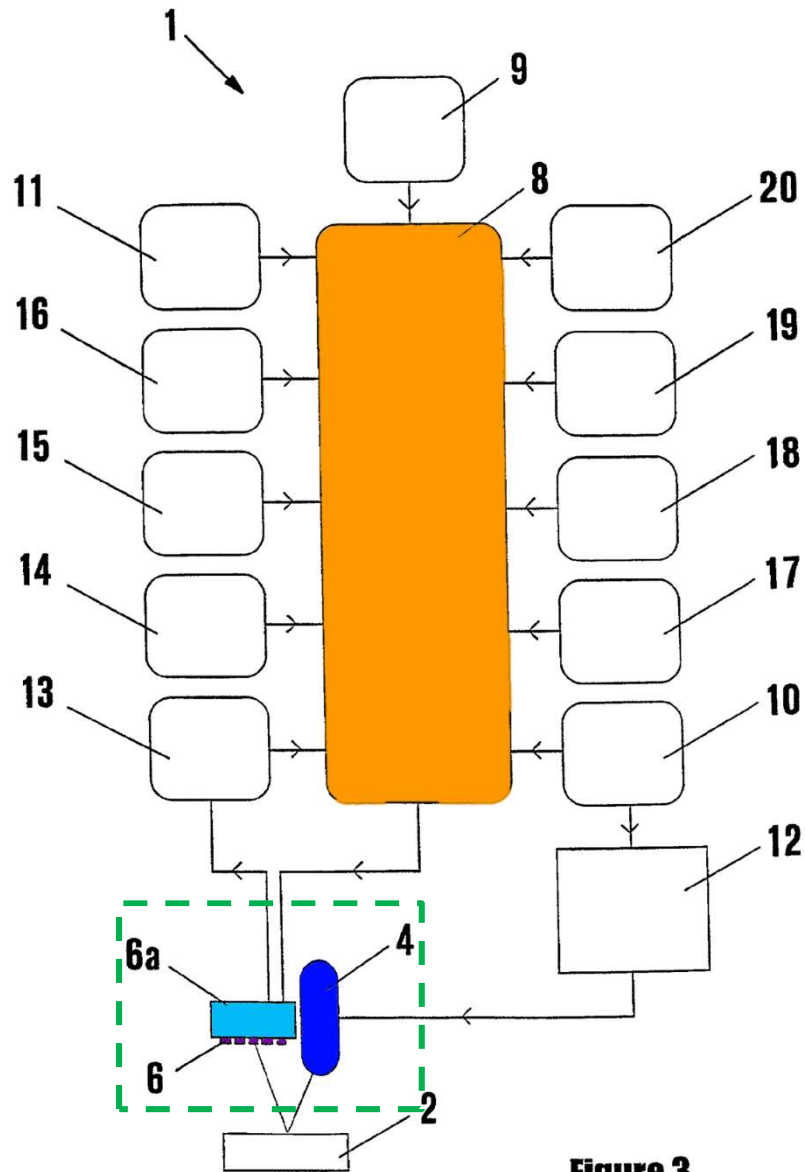


Figure 3

Computer
Active Light Sensor
Light Source
Light Sensor Array / Sensors

Gallagher, Fig. 3 (annotated).

Gallagher's computer 8 detects objects of interest (e.g., road markings and markers) within the field of view because Gallagher discloses that "background

reflectance levels on non[-]road marking sections of the road are low” and the reflectance levels of the objects of interest are “relatively high,” allowing Gallagher’s computer 8 to detect objects of interest based on “which light sensor 6 is reading the highest reflectance reading.” Gallagher, [0033], [0060]; Thorpe ¶72. Gallagher’s computer 8 then “provide[s] the operator with that information” so that the driver can maintain the vehicle in a position that has “the most central of the light sensors 6 detecting the highest reflectance levels.” Gallagher, [0060]-[0062]; Thorpe ¶72. Gallagher’s computer 8 then “determine[s] the location of each road marking” (objects of interest), which “is used to tag or identify the road markers tested along a stretch of road.” Gallagher, [0063]-[0064]; Thorpe ¶72.

- d. [9E]: “determine whether the object of interest includes at least one light intensity value associated with a reflective surface of a road marker in the field of view; and”**

Gallagher discloses or at least suggests [9E]. Thorpe ¶¶73-74.

Gallagher discloses its computer 8 obtaining “the data ... on the reflected light detected by the light sensors 6,” “determining the background reflectance level on the road and establishing non-marker reflectance levels,” and “selecting, from data obtained ..., which reflectance levels indicate” a reflective surface of a road marker (e.g., painted lines and/or raised pavement marker) (determining whether the object of interest includes at least one light intensity value associated with a reflective surface of a road marker in the field of view). Gallagher, [0033],

[0055]-[0056], [0065]-[0066]; Thorpe ¶74. Accordingly, Gallagher uses the light intensity values from the light sensors to determine whether objects of interest (e.g., painted lines and/or raised pavement markers) include a reflective surface by distinguishing their reflectance levels from the “non-marker reflectance levels.” Gallagher, [0065]-[0066]; Thorpe ¶74. 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].

- e. **[9F]: “analyze the at least one light intensity value to determine an assessment of a discrete location of the road marker within the field of view.”**

Gallagher and Schofield render obvious [9F]. Thorpe ¶¶75-80.

A POSITA would have found it obvious to implement Schofield’s determination of a light source’s location within a field of view to distinguish between different types of road markers. Schofield, 9:26-32; Thorpe ¶76. Schofield discloses that the sensors in its light-imaging array “divide the scene forward of the vehicle into spatially separated regions, and light sources are identified, at least in part, according to their spatial distribution across the regions.” Schofield, 2:36-41, 9:26-32; Thorpe ¶76.

A POSITA would have been motivated to implement Schofield’s determination of a light source’s location within a field of view because doing so would have improved Gallagher’s computer by allowing it to differentiate between

road markers “that are spaced apart on the road.” Gallagher, [0040], [0043];

Thorpe ¶77. Gallagher discloses using its apparatus to measure the reflectivity of road markers that are “arranged side by side on either side of a cent[er]line,” where “[r]eflected light from these markers can be detected simultaneously by” separate light sensors in the array. Gallagher, [0040]; Thorpe ¶77. Gallagher discloses that it is desirable to select a light source with a wider beam when “testing markers 2 that are spaced apart on the road.” Gallagher, [0043]. In this situation, a POSITA would have seen Schofield’s determination of a light source’s location within the field of view as advantageous because it would have allowed Gallagher’s computer to associate the measured reflectance level with the appropriate road marker. Doing so would have improved Gallagher’s system by allowing more specificity in indicating which road markers (e.g., left or right at a particular location) were “determined as measuring a reflectivity less than the predetermined minimum acceptable reflectance level.” Gallagher, [0068]; Thorpe ¶77.

Moreover, a POSITA would have been motivated to implement Schofield’s determination of a light source’s location within a field of view because Schofield discloses that doing so would improve object identification through spatial filtering and pattern recognition. Schofield, 10:51-11:12; Thorpe ¶78. Schofield discloses that, when objects of interest “usually occur in pairs,” this fact “could be used to assist in qualifying or disqualifying objects as” objects of interest. Schofield, 11:3-

6. A POSITA would have been motivated to apply this pattern recognition to improve the identification of markers “arranged side by side on either side of a cent[er]line.” Gallagher, [0040]; Thorpe ¶78.

A POSITA would have reasonably expected success in determining an assessment of a discrete location of the road marker within the field of view based on the at least one light intensity value because Schofield discloses implementing this technique using a photosensing array of “photo diodes,” and Gallagher similarly discloses that the light sensors 6 in its light sensor array 6a are photodiodes. Schofield, 2:36-41, 8:38-45, 9:26-32, 10:51-11:12; Gallagher, [0039], [0041]; Thorpe ¶79. Accordingly, implementing this determination would have required a POSITA to implement only conventional techniques of image processing (identifying a location of a particular pixel within an array) to predictably yield the location within a field of view indicating an intensity value associated with a road marker. Thorpe ¶79. Given that Schofield and Gallagher disclose similar types of arrays, this combination would have merely required the use of Schofield’s known technique to improve Gallagher’s similar device in the same way. Thorpe ¶79.

To the extent Patent Owner contends or the Board finds that “a discrete location of the road marker within the field of view” refers to a location in 3-D space, this also would have been obvious because Gallagher discloses

“determin[ing] the location of each road marking” using either the vehicle’s “gearbox revolution sensor 14” or a “GPS interface 15” “as measurements are being taken.” Gallagher, [0048], [0063]; Thorpe ¶80. This location corresponds to a discrete location that is within the 3-D space covered by the sensor array’s field of view. Gallagher, [0009], [0038], [0048], [0063]; Thorpe ¶80.

5. Claim 10: “The automated system of claim 9, wherein the road marker is selected from a set consisting of pavement markings and road signs.”

Gallagher discloses the additional limitation of claim 10.² Thorpe ¶¶81-82.

As discussed for [9E], the road marker is reflective painted lines on a road and/or raised pavement markers (pavement markings). Gallagher, [0033], [0066]; *supra* Section IV.A.4.d; Thorpe ¶82. Additionally, Gallagher discloses adapting its reflectivity measuring apparatus to measure the reflectivity of “road signs.” Gallagher, [0033]; Thorpe ¶82.

² Demonstrating unpatentability of a Markush group claim only requires demonstrating that “one element of the group is anticipated or obvious.” *Ecolochem, Inc. v. S. Cal. Edison Co.*, 91 F.3d 169, 1996 WL 297601, at *2 (Fed. Cir. June 5, 1996) (unpublished table decision); *see Abbott Lab’ys v. Baxter Pharm. Prods., Inc.*, 334 F.3d 1274, 1280 (Fed. Cir. 2003) (Markush group elements are “alternatively usable” (citation omitted)).

6. Claim 11: “The automated system of claim 9, wherein the computer processing system is configured to operate in a mode selected from post-processing or on-the-fly.”

Gallagher discloses the additional limitation of claim 11. Thorpe ¶¶83-84.

Gallagher discloses making measurements “in real time” (on-the-fly), allowing the computer to tag any “faulty or unacceptable marker 2” “as the vehicle 3 is passing” them. Gallagher, [0051], [0072]; Thorpe ¶84.

7. Claim 12: “The automated system of claim 9, wherein the light source is selected from the set consisting of a laser scanning device, a strobe light, or a vehicle headlight lamp.”

Gallagher discloses the additional limitation of claim 12. Thorpe ¶¶85-86.

As discussed for [9B], light source 4 is “a standard vehicle headlight” (vehicle headlight lamp). Gallagher [0035]; *supra* Section IV.A.4.b; Thorpe ¶86.

8. Claim 13: “The automated system of claim 9, wherein the computer processing system is further configured to associate at least one color with the reflective characteristic of the road marker to confirm the assessment that what is positioned at the discrete location within the field of view is a road marker, wherein the at least one color is selected from a set of colors consisting of yellow, green, red and white.”

Gallagher and Schofield render obvious the additional limitations of claim 13. Thorpe ¶¶87-92.

Gallagher discloses one embodiment where the light sensors are “photodiodes mounted precisely ... at a height and angle to properly detect reflected light.” Gallagher, [0039]. Gallagher also discloses that “[a] variety of

light sensors” are “suitable.” *Id.* 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.” *Id.*; Thorpe ¶88. When using Gallagher’s apparatus “to test different [colored] road markings simultaneously,” a POSITA would have found it obvious to implement in Gallagher’s computer processing system Schofield’s use of color to confirm the object identification, associating 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 thereby confirm the assessment that what is positioned at the discrete location within the field of view is a road marker. Gallagher, [0039]; Thorpe ¶88.

Schofield discloses using color to assist in identifying objects of interest because Schofield 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; Thorpe ¶89. Schofield also teaches that “[l]ane markers ... may be readily identified by spectral signature.” Schofield, 10:43-45.

A POSITA would have been motivated to implement Schofield’s use of color to confirm the object identification because Gallagher suggests such a

combination, as Gallagher discloses using its apparatus to sense “[colored] markers” and “to test different [colored] road markings simultaneously.”

Gallagher, [0039]; Thorpe ¶90. This would have suggested to a POSITA implementing Schofield’s object identification using spectral signature to assist in assessing the type of road marker with which an identified reflective surface is associated. Thorpe ¶90.

Road markers were well known to be various colors, including yellow, green, red, and white, each of which indicates different information to the driver. ASTM, 452-453 (disclosing white, yellow, red, blue, and green raised retroreflective pavement markers); Thorpe ¶91. Each color of road marker required a different reflectance level. ASTM, 452-453; Thorpe ¶91. A POSITA would have been motivated to implement Schofield’s use of color to confirm that the color of the detected object corresponded to a color of a road marker being tested, such as yellow, green, white, or red. Thorpe ¶91. This would have beneficially allowed Gallagher’s computer to associate the required reflectance level for those colors with the reflective characteristic (e.g., its reflectance level in terms of the CIL value) of the road marker and determine whether it meets the corresponding “predetermined minimum acceptable reflectance level” associated with each colored road marker. Gallagher, [0068]; Thorpe ¶91.

A POSITA would have reasonably expected 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]; Thorpe ¶92. Schofield also discloses that “reflectivity” and “spectral characteristics” may be used together to identify objects of interest. Schofield, 11:1-3; Thorpe ¶92. Accordingly, combining Gallagher and Schofield to associate yellow, white, or red with a reflective characteristic of the road marker to confirm the assessment that the reflective surface is a road marker would have required a POSITA to apply only conventional techniques of associating a color with reflectivity to predictably yield a confirmation of the reflective-surface assessment. Thorpe ¶92.

9. Independent Claim 17

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

Gallagher discloses [17P] for the reasons discussed regarding [9P]. *Supra* Section IV.A.4.a; Thorpe ¶93.

- b. **[17A]: “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;”**

Gallagher discloses a light source to illuminate an area that includes the at least one reflective surface on a road marker for the reasons discussed regarding [9B]. *Supra* Section IV.A.4.b; Thorpe ¶94. 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, [0046]; Thorpe ¶94. This causes light source 4 to “illuminate[] a reflective surface of a marker 2.” Gallagher, [0046]; Thorpe ¶94. The apparatus measures the road marker’s reflectivity level (a reflective characteristic). Gallagher, [0032]-[0033], [0066]-[0068]; Thorpe ¶94.

- c. **[17B]: “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”**

[17B] is substantively identical to [9C]. Thus, Gallagher discloses or suggests [17B] for the reasons discussed regarding [9C]. *Supra* Section IV.A.4.b; Thorpe ¶95. Because the light sensors measure a plurality of light intensity values, a POSITA would have understood Gallagher’s light sensor module to disclose at least one intensity sensor. *Supra* Section IV.A.4.b; Thorpe ¶95.

- d. **[17C]: “using a computer processing system configured to: identify 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 in the field of view; and”**

[17C] is substantively identical to [9D]-[9E]. Thus, Gallagher discloses or Gallagher and Schofield render obvious [17C] for the reasons discussed regarding [9D]-[9E]. *Supra* Sections IV.A.4.c-IV.A.4.d; Thorpe ¶96.

- e. **[17D]: “analyze the at least one light intensity value of the plurality of light intensity values to determine an assessment of a discrete location of the road marker within the field of view.”**

[17D] is substantively identical to [9F]. Thus, Gallagher and Schofield render obvious [17D] for the reasons discussed regarding [9F]. *Supra* Section IV.A.4.e; Thorpe ¶97.

- 10. **Claim 18: “The automated method of claim 17, wherein the computer processing system is further configured to associate at least one color with the reflective characteristic of the road marker to confirm the road marker at the discrete location within the field of view, wherein the at least one color is selected from a set of colors consisting of yellow, green, red and white.”**

The additional limitations of claim 18 are substantively identical to those in claim 13. Thus, Gallagher and Schofield render obvious the additional limitations of claim 18 for the reasons discussed for claim 13. *Supra* Section IV.A.8; Thorpe ¶98.

11. Independent Claim 1

- a. **[1P]: “An automated system that detects and determines reflective surfaces of interest in a scene of non-retroreflective surfaces along a roadway that is being traversed by a vehicle, the automated system comprising:”**

If limiting, Gallagher discloses [1P]. Thorpe ¶¶99-100.

Gallagher discloses an automated system that detects and determines reflective surfaces of interest in a scene of non-retroreflective surfaces along a roadway that is being traversed by a vehicle using its reflectivity measuring apparatus. Gallagher, [0033]-[0035]; Thorpe ¶100. Gallagher’s apparatus detects and determines reflective surfaces of interest along a roadway that is being traversed by a vehicle because it is mounted on a moving vehicle and 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 the reflected-light data; selects “which reflectance levels indicate a road marker”; “determin[es] the reflectance level of the road marker in a value of millicandela per Lux (CIL)”; and stores “the location and CIL levels of each road marker” tested. Gallagher, [0032], [0046], [0055]-[0069]; Thorpe ¶100. This system tags any road markers determined to have “a reflectivity less than the predetermined minimum acceptable reflectance level.” Gallagher, [0068]. This detecting and determining occurs in a scene of non-reflective surfaces because

Gallagher discloses that “background reflectance levels on non[-]road marking sections of the road are low.” Gallagher, [0060]; Thorpe ¶100. This system is automated because the computer automatically measures reflectivity “in real time.” Gallagher, [0046], [0071]; Thorpe ¶100.

b. [1A]: “an image capture system that captures images within a field of view along the roadway;”

Gallagher and Schofield render obvious [1A]. Thorpe ¶¶101-107.

Schofield discloses [1A] because it discloses “an imaging sensor module 14” that is mounted “to, or near, the vehicle’s windshield” to “sense[] light from a scene forward of [a] vehicle.” Schofield, 3:64-66, 3:36-44; Thorpe ¶102. The imaging sensor module captures images “forward of the vehicle” (images within a field of view along the roadway) using “an optical device 36, such as a lens,” and “a charge couple device (CCD) array of the type commonly utilized in video camcorders and the like.” Schofield, 4:16-21, 8:38-40, 11:44-47, 12:8-11. Figure 11a, below, depicts one such image within a field of view along a roadway. Schofield, 3:29-30, Fig. 11a; Thorpe ¶102. Schofield’s imaging sensor module captures “frames” (images), which may be used to enhance its object recognition “by comparing identified objects over successive frames.” Schofield, 11:8-12; Thorpe ¶102.

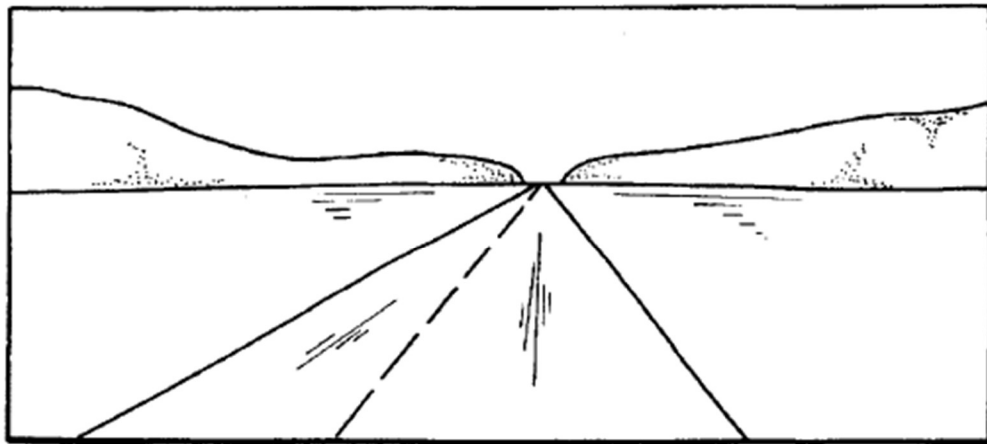


FIG. 11a

Schofield, Fig. 11a.

A POSITA would have been motivated to incorporate Schofield's imaging sensor module 14 into Gallagher's apparatus to improve the apparatus' ability to identify objects of interest along the roadway. Schofield, 9:24-26, 10:18-11:12, 11:58-12:46; Thorpe ¶103. Schofield discloses applying "[p]attern recognition" to "assist in the detection of ... objects of interest," where this pattern recognition "identifies objects of interest based upon their shape, reflectivity, luminance, and spectral characteristics" (e.g., color). Schofield, 10:66-11:12. Accordingly, a POSITA would have seen Gallagher's reflectivity measuring apparatus, which measures reflectivity, and Schofield's imaging sensor module 14, which enables the identification of objects through things like their shape and spectral characteristics, as complementary systems that, through pattern recognition, would advantageously work together to improve object identification. Gallagher, [0055]-

[0067]; Schofield, 9:24-26, 10:18-11:12, 11:58-12:46; Thorpe ¶103. A POSITA would have been motivated to incorporate the data from Schofield's imaging sensor module into the processing performed by Gallagher's "powerful" computer to improve road-marker identification. Gallagher, [0050]-[0072]; Thorpe ¶103.

Moreover, Gallagher's apparatus and Schofield's imaging sensor module both identify road signs and road markers using different characteristics, suggesting to a POSITA that performing Schofield's pattern recognition using Gallagher's computer, based on data from Gallagher's light sensor module and Schofield's imaging sensor module, would further improve the road-sign and road-marker identification. Gallagher, [0031]-[0033]; Schofield, 10:66-11:12, 12:1-4, 12:40-42; Thorpe ¶104. Accordingly, a POSITA would have seen incorporating Schofield's imaging sensor module into Gallagher's apparatus as combining well-known prior-art elements according to known methods to predictably yield a system that improves object detection. Thorpe ¶104. Indeed, a POSITA would have known that incorporating a separate video camera in a mobile system for measuring retroreflectivity of road markings, like Gallagher's, had several advantages, including simultaneously recording "the driver's view and numerical performance data." Ex. 1020, 4:16-43, 7:46-8:3, Fig. 10; Thorpe ¶104.

Gallagher suggests the desirability of this combination. Thorpe ¶105. Gallagher discloses that presenting data "in real time on a monitor" helps assess

“whether the apparatus is measuring accurately.” Gallagher, [0052], [0071]-[0072]; Thorpe ¶105. Likewise, a POSITA would have been motivated to display a video feed from Schofield’s imaging sensor module to allow operators to assess whether the apparatus is working properly, by allowing the operator to easily determine whether it is identifying all of the road markers. Gallagher, [0068]-[0072]; Thorpe ¶105.

A POSITA would have reasonably expected success in combining Gallagher and Schofield. Thorpe ¶106. A POSITA would have seen Gallagher’s reflectivity measuring apparatus and Schofield’s system as complementary because both are used to identify road markings like traffic signs and lane markers in real time from a moving vehicle. Gallagher, [0031]-[0033], [0072]; Schofield, 12:1-4, 12:40-42; Thorpe ¶106. Accordingly, a POSITA would have needed to apply only conventional techniques of incorporating Schofield’s imaging sensor module into Gallagher’s reflectivity measuring apparatus to predictably carry out Gallagher’s road-marker testing. Thorpe ¶106.

Moreover, Gallagher’s apparatus uses a computer with processing speed “powerful enough to be capable of processing the incoming data.” Gallagher, [0035], [0038]-[0039], [0050]; Thorpe ¶107. A POSITA would have reasonably expected success with Gallagher’s “powerful” computer handling the data processing. Gallagher, [0050]; Thorpe ¶107. Indeed, Schofield describes

processing data from its imaging sensor module using “a suitably programmed micro-processor with input and output buffers,” further leading a POSITA to expect success from processing the necessary data using the processor in Gallagher’s computer. Schofield, 5:46-49; Thorpe ¶107. Implementing Schofield’s imaging sensor module into Gallagher’s reflectivity measuring apparatus would have been a straightforward application of known components and software operations (sending data from Schofield’s imaging sensor module to Gallagher’s “powerful” computer) used according to their known functions to yield predictable results (processing data from both Gallagher’s light sensor module and Schofield’s imaging sensor module to improve the object identification). Thorpe ¶107.

- c. **[1B]: “an active light sensor including;” [1C]: “a light source that illuminates an area along the roadway; and” [1D]: “a light sensor that measures light intensity values within at least a portion of the area illuminated by the light source; and”**

Gallagher renders obvious [1B] and its sub-elements [1C] and [1D] for the reasons discussed regarding [9A] and its sub-elements [9B] and [9C]. *Supra* Section IV.A.4.b; Thorpe ¶108.

- d. **[1E]: “a computer processing system operably connected to the image capture system, and the active light sensor and configured to detect objects of interest within the field of view and for each object of interest:”**

Gallagher and Schofield render obvious [1E]. Thorpe ¶¶109-111.

Gallagher discloses a computer processing system operably connected to the active light sensor and configured to detect objects of interest within the field of view for the reasons discussed for [9D]. *Supra* Section IV.A.4.c; Thorpe ¶110. For the reasons discussed regarding [1A], a POSITA would have found it obvious to operably connect Gallagher’s computer processing system—a computer “powerful enough” to process incoming data—to Schofield’s imaging sensor module to further improve the detection of objects of interest (e.g., reflective painted lines and raised pavement markers) within the field of view. Gallagher, [0033], [0050]; *supra* Section IV.A.11.b; Thorpe ¶110.

Schofield discloses detecting objects like “[l]ane markers, signs, and other sources of reflected light” within its field of view using their “spectral signature” and ignoring “non-relevant light sources” based on analyzing their “spectral signature[s].” Schofield, 10:20-29, 10:43-45; Thorpe ¶111. As discussed for [1A], configuring Gallagher’s computer 8 to perform this object detection would have advantageously “assist[ed] in the detection of ... objects of interest.” Schofield, 10:66-11:12; Gallagher, [0055]-[0066]; *supra* Section IV.A.11.b; Thorpe ¶111.

- e. **[1F]: “determine whether the object of interest includes a reflective surface based on the light intensity values;”**

Gallagher discloses [1F]. Thorpe ¶¶112-113.

Gallagher's apparatus "can test the reflectivity" of various lane markers, including "painted lines" and "raised pavement markers 2" "fastened or secured along lanes." Gallagher, [0033]-[0034]; Thorpe ¶113. Gallagher discloses its computer 8 obtaining the reflected-light data from the light sensors 6, "determining the background reflectance level on the road and establishing non-marker reflectance levels," and "selecting, from data obtained ..., which reflectance levels indicate" a reflective surface of a marker. Gallagher, [0055]-[0056], [0065]-[0066]; Thorpe ¶113. Accordingly, Gallagher uses the light intensity values from the light sensors 6 to determine whether lane markers, including the painted lines of the lane and raised pavement markers fastened along the lane, include a reflective surface by distinguishing their reflectance levels from the "non-marker reflectance levels." Gallagher, [0033], [0065]-[0066]; Thorpe ¶113. 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].

f. [1G]: "determine whether the reflective surface is a road marker based on an assessment of the reflective surface; and"

Gallagher discloses [1G]. Thorpe ¶¶114-115.

Gallagher discloses that, "[i]n the case of road markers[,], the peak responses sensed are determined as the highly reflective surfaces of a road marker."

Gallagher, [0066]. Accordingly, Gallagher discloses determining that a reflective

surface is a raised pavement marker (road marker) based on assessing whether the reflectivity of the reflective surface indicates a “peak response[.]” *Id.*;

Thorpe ¶115.

g. [1H]: “determine a location of the road marker.”

Gallagher discloses [1H]. Thorpe ¶¶116-117.

Gallagher discloses using a GPS interface or “a vehicle gearbox revolution sensor” to “determin[e] the location of a road marking.” Gallagher, [0008], [0020], [0048]. Gallagher’s apparatus then “stores data measured on the ... location of each ... road marking tested.” Gallagher, [0012], [0022]; Thorpe ¶117.

12. Claim 2: “The automated system of claim 1, wherein the road marker is an object of interest selected from the set consisting of a road sign or a pavement marker.”

Schofield and Gallagher render obvious the additional limitations of claim 2. Thorpe ¶¶118-119.

As discussed for [1G] and [1H], the road marker is a raised pavement marker (pavement marker). Gallagher, [0033], [0063]-[0064], [0066]; *supra* Sections IV.A.11.f, IV.A.11.g; Thorpe ¶119.

13. Claim 3: “The automated system of claim 1, wherein the computer processing system is configured to operate in a mode selected from post-processing or on-the-fly.”

Gallagher discloses that the computer processing system is configured to operate in an on-the-fly mode for the reasons described regarding claim 11. *Supra* Section IV.A.6; Thorpe ¶120.

- 14. Claim 4: “The automated system of claim 1, wherein the light source is selected from the set consisting of a laser scanning device, a strobe light, or a vehicle headlight lamp.”**

Gallagher discloses that the light source is a vehicle headlight lamp for the reasons described regarding claim 12. *Supra* Section IV.A.7; Thorpe ¶121.

- 15. Claim 8: “The automated system of claim 1, wherein the computer processing system is further configured to associate at least one color with the reflective characteristic of the road marker to confirm the assessment that the reflective surface is a road marker, wherein the at least one color is selected from a set of colors consisting of yellow, green, red and white.”**

Gallagher and Schofield render obvious the additional limitations of claim 8. Thorpe ¶¶122-126.

When using Gallagher’s apparatus “to test different [colored] road markings simultaneously,” a POSITA would have found it obvious to implement Schofield’s use of color in Gallagher’s computer processing system to confirm the object identification, associating at least one color (e.g., yellow, red, and/or white) with the reflective characteristic of the road marker to confirm the road-marker assessment. Gallagher, [0039]; Thorpe ¶123.

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; Thorpe ¶124. Schofield also teaches that “[l]ane markers ... may be readily identified by spectral signature.” Schofield, 10:43-45.

As discussed for claim 13, a POSITA would have been motivated to associate at least yellow, white, or red with the reflective characteristic of the road marker to confirm the assessment that a reflective surface is a road marker. Gallagher, [0068]; *supra* Section IV.A.8; Thorpe ¶125.

A POSITA would have reasonably expected success because Schofield teaches different techniques for associating yellow, white, and red with other characteristics of a particular object (e.g., associating pairs of white light sources with oncoming headlights, yellow triangles with caution signs, and red octagons with stop signs). Schofield, 10:35-50, 11:1-6, 12:1-8; Thorpe ¶126. Schofield also discloses that “reflectivity” and “spectral characteristics” may be used together to identify objects of interest. Schofield, 11:1-3; Thorpe ¶126. Accordingly, combining Gallagher and Schofield to associate yellow, white, or red, as determined from analyzing the data from Schofield’s imaging sensor module, with a reflective characteristic of the road marker, as determined from analyzing the data from Gallagher’s light sensor array, to confirm the assessment that the reflective surface is a road marker would have required a POSITA to apply only

conventional techniques of associating a color with reflectivity to predictably yield confirming the assessment of the reflective surface. Thorpe ¶126.

**B. Ground 2: Gallagher, Schofield, and Frank Render Obvious
Claims 15-16, 19, and 21-22**

1. Frank

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; Thorpe ¶¶127-129. 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.

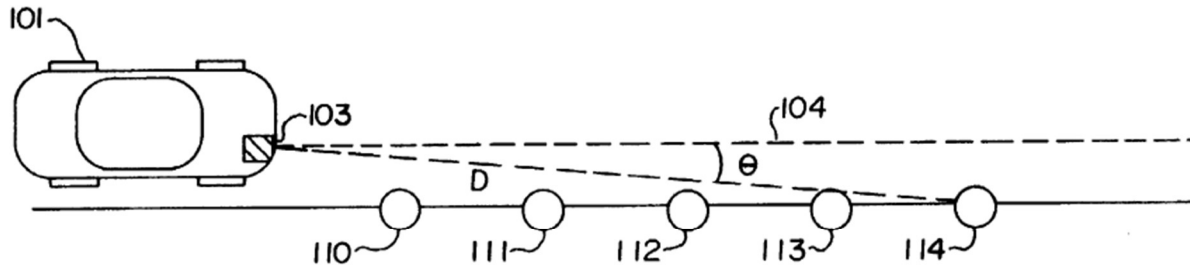


FIG. 2

Frank, Fig. 2.

A laser 332 produces 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 mirror surface 330 oscillates, 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 a predetermined area sized similarly 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” to an effective distance 122, limited by “attenuation effects of the atmosphere” on the beam. Frank, 6:12-49.

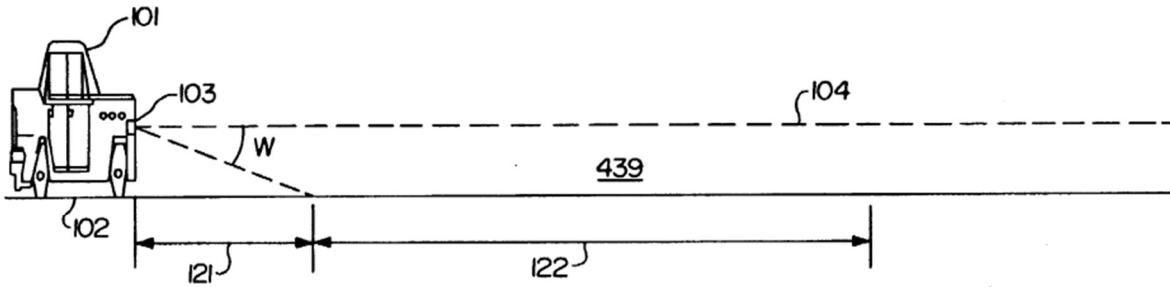


FIG. 1A

Frank, Fig. 1A.

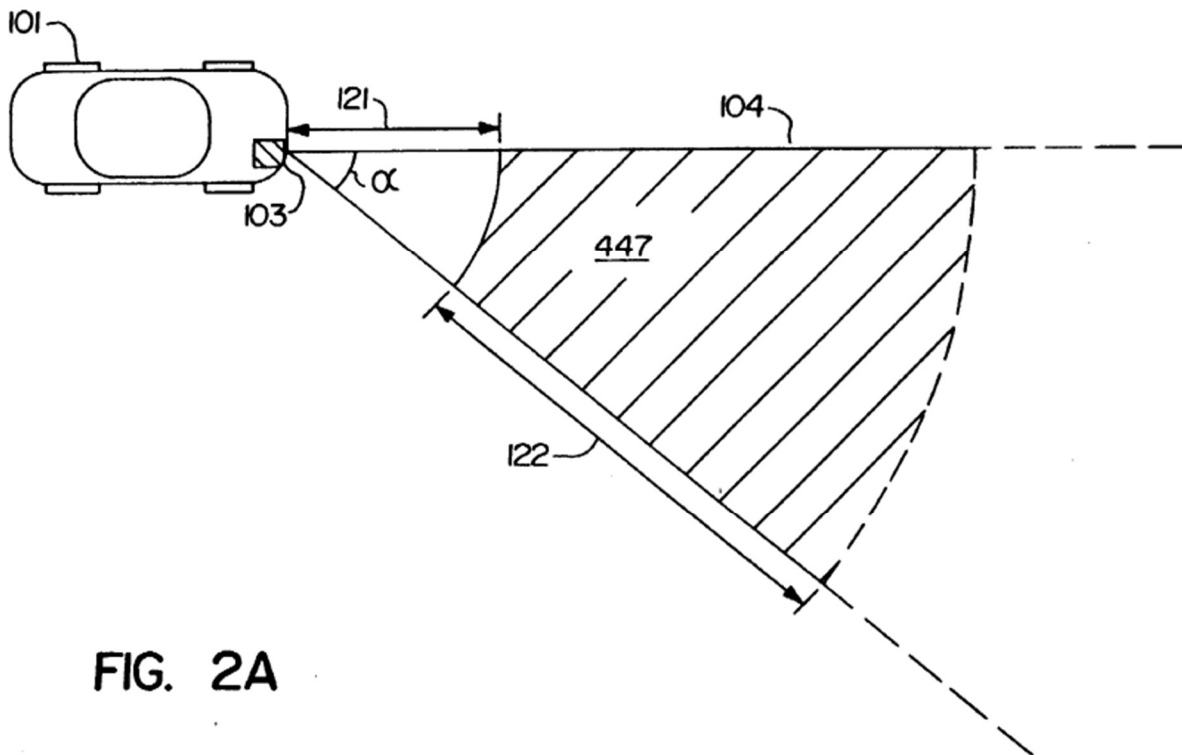


FIG. 2A

Frank, Fig. 2A.

A “receiving apparatus 465,” including optical receiver 442 that “receives the reflected light beams” and receiver electronics 443, 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.

2. Frank Is Analogous Art

Frank is analogous art to the '328 patent because it is in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:31-32; Frank, 6:4-11; Thorpe ¶130. Frank is also analogous art to the '328 patent because it is reasonably pertinent to problems addressed by the '328 patent, including automatically identifying road markers without relying solely on “template matching of shape and color.” Ex. 1001, 1:39-47; Frank, 7:27-50 (identifying retroreflectors using “reflected light ... transmitted back to [a] laser radar apparatus”); Thorpe ¶130.

3. Claim 15: “The automated system of claim 9, wherein the computer processing system is further configured to determine exemplary angular displacements of incident light for each light intensity measurement from a reference position relative to the field of view as part of the assessment of the discrete location of the road marker within the field of view.”

Gallagher and Frank render obvious the additional limitations of claim 15. Thorpe ¶¶131-137.

Gallagher discloses taking multiple light intensity measurements, explaining that its reflectivity measuring apparatus “is capable of sampling road marking reflectance level data at frequent intervals” and smooths the sampled data “by

calculating the average reflectance level from a set of sampled data from each sensor.” Gallagher, [0047], [0057]; Thorpe ¶132. Gallagher also discloses an observation angle (exemplary angular displacement of incident light) that “is the angle between the incident and reflected light.” Gallagher, [0041]; Thorpe ¶132. Gallagher discloses mounting its light sensor module 6a in a way “to reduce the observation angle to almost zero” and “to account for road[] authorities standards.” Gallagher, [0041]. Gallagher discloses that the observation angle “is generally about 0.2 degrees.” *Id.*; Thorpe ¶132.

A POSITA would have understood that the observation angle depends on the distance to the road marker. Ex. 1015, 67 (disclosing that the observation angle changes as the vehicle gets closer to the reflective surface); Thorpe ¶133. It was well known that the observation angle changes as the position of the vehicle relative to the road marker (a reference position relative to the field of view) changes. Ex. 1015, 67; Ex. 1014, 21; Thorpe ¶133. A POSITA would have found it obvious to incorporate Frank’s pulse-modulated light source as Gallagher’s light source to enable Gallagher’s computer 8 to determine the “distance D between vehicle 101 to the retroreflector” for each reference position relative to the field of view to accurately determine an observation angle for each light intensity measurement. Frank, 4:37-42; Thorpe ¶133.

Frank, similar to Gallagher, discloses an apparatus mounted on a moving vehicle that identifies retroreflectors along a roadway. Frank, 4:10-51, 6:4-11; Thorpe ¶134. In one embodiment, Frank's light source is a laser diode 932 that "outputs floodlight beam 946 covering all of predetermined area 947," similar to Gallagher's light source. Frank, 10:54-58. An optical receiver "receives light pulses reflected back from retroreflectors" and, based on "[t]he time delay between the transmitted and received pulses," the apparatus calculates "the distance D between vehicle 101 and each retroreflector." Frank, 10:61-67; Thorpe ¶134. Frank's optical receiver is a "photodiode array" or any "other type of photosensitive array." Frank, 10:67-11:4, 13:64-14:15; Thorpe ¶134.

A POSITA would have been motivated to implement Frank's laser diode that outputs a pulse-modulated floodlight beam as Gallagher's light source and to implement Frank's determination of the distance to each identified retroreflector to improve Gallagher's determination of the observation angle. Thorpe ¶135. Gallagher assumes that the observation angle "is generally about 0.2 degrees." Gallagher, [0041]. But it was well known that the observation angle changes as the distance between the vehicle and the reflective surface changes. Ex. 1015, 67; Ex. 1014, 21; Thorpe ¶135. For example, the observation angle changes "rapidly" once the vehicle gets close to the retroreflective surface. Ex. 1015, 67; Thorpe ¶135. For a "fixed source-detector separation" in a moving system like

Gallagher's, it was well known to implement techniques to determine "the actual distance to the target" and take measurements within "a 'distance window'" "to maintain sufficient accuracy." Ex. 1014, 15, 21, 24; Thorpe ¶135. A POSITA would have understood that, based on a known, fixed geometry between the light source and light sensor, the distance to the measured reflective surface would have allowed the observation angle to be estimated. Thorpe ¶135.

Gallagher discloses that its "beam projects a short distance to account for various road conditions and placement of markers," motivating a POSITA to determine the observation angle for each of its light intensity measurements and select those measurements whose observation angle aligns with "road[] authorities standards." Gallagher, [0037], [0041]; Thorpe ¶136. For example, certain road authorities standards required measurement of retroreflective raised pavement markers from an observation angle of 0.2°. ASTM, 453 (Table 1); Thorpe ¶136. Doing so would have been desirable because reflectivity was known to vary with observation angle, so determining the observation angle of each of Gallagher's light intensity measurements would have improved its ability to determine whether a surface's reflectivity measures "less than the predetermined minimum acceptable reflectance level." Gallagher, [0068]; Thorpe ¶136.

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]; Thorpe ¶137. 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 and well-known mathematics to determine distance and the corresponding observation angle based on the light intensity values for each light intensity measurement using "[t]he time delay between the transmitted and received pulses." Frank, 10:64-67, Ex. 1014, 24; Thorpe ¶137.

4. **Claim 16: "The automated system of claim 15, wherein each of the exemplary angular displacements of incident light comprises an observation angle corresponding to one of a plurality of distances of the light source from the road marker."**

Gallagher and Frank render obvious the additional limitations of claim 16 for the reasons stated regarding claim 15. *Supra* Section IV.B.3; Thorpe ¶138.

5. **Claim 19: "The automated method of claim 17, further wherein the computer processing system is further configured to determine a lateral distance between the light source and the illuminated portion of the reflective road marker."**

Gallagher and Frank render obvious the additional limitations of claim 19. Thorpe ¶¶139-143.

As discussed for claim 15, a POSITA would have found it obvious to incorporate Frank's pulse-modulated light source as Gallagher's light source to enable Gallagher's computer 8 to determine the "distance D between vehicle 101 to the retroreflector" for each reference position. *Supra* Section IV.B.3; Frank, 4:37-42; Thorpe ¶140.

Frank additionally discloses determining the angle between the light source and the retroreflector "using a photodiode array" or another "type of photosensitive array." Frank, 10:67-11:4, 13:64-14:15; Thorpe ¶141. Frank discloses that "[t]he position of the received light pulse" on the array is "indicative of the angle θ at which the retroreflector lies in relation to vehicle axis 104," labeled in Figure 2, below. Frank, 11:2-4, 12:33-39, 13:16-21; Thorpe ¶141. From the distance measurement and the angle θ , a POSITA would have understood that determining the lateral distance between the light source and the illuminated portion of the reflective road marker would have been a simple matter of trigonometry: (**lateral distance**= $D \cdot \sin(\theta)$). Thorpe ¶141.

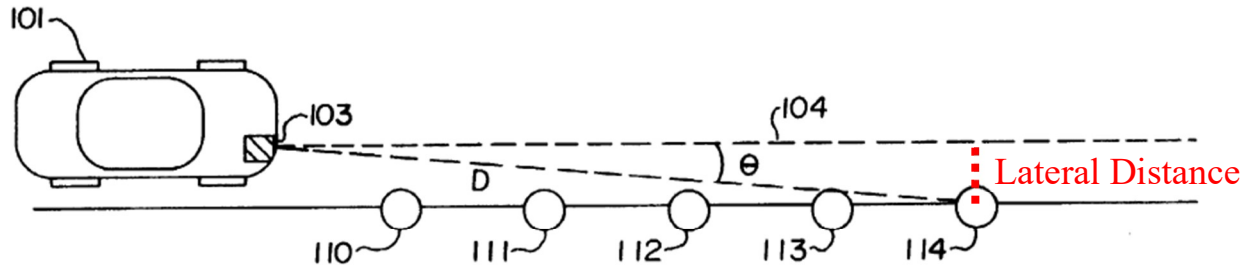


FIG. 2

Frank, Fig. 2 (annotated).

A POSITA would have found it obvious to incorporate Frank's determination of the distance D and angle θ to allow Gallagher's computer to easily calculate the lateral distance between the light source and the illuminated portion of the reflective road marker. Thorpe ¶142. A POSITA would have been motivated to do so to provide the driver with an indication of the lateral distance between the vehicle and the road markers, and accordingly assist in keeping the road markers within the apparatus' measuring area. Thorpe ¶142. Gallagher suggests to a POSITA that such a combination would have been desirable. Gallagher, [0060]-[0062]; Thorpe ¶142. Gallagher discloses "determining the vehicle position on the road and providing an audio and/or visual indicator means for the operator of the vehicle 3," which "enables the operator to maintain the vehicle 3 in a proper position on the road to allow the apparatus 1 to obtain reflectivity measurements." Gallagher, [0060]. A POSITA would have understood

that the lateral distance between the apparatus' light source and the road markers would have been one simple way to provide the vehicle driver with the vehicle's "position on the road." *Id.*; Thorpe ¶142. Given the finite number of ways to characterize a vehicle's position on the road relative to the road markers, the lateral distance would have been one identified, predictable solution, akin to Gallagher's example of informing the operator "which light sensor 6 is reading the highest reflectance reading." Gallagher, [0060]; Thorpe ¶142.

A POSITA would have reasonably expected success for the reasons stated regarding claim 15. *Supra* Section IV.B.3; Thorpe ¶143. Additionally, it would have required applying only conventional data-processing techniques (identifying an angle from a photosensor array and applying basic trigonometry) to yield the predictable result of lateral-distance calculations that would help the driver maintain the vehicle in the proper position on the road relative to the road markers. Thorpe ¶143.

6. **Claim 21: "The automated method of claim 17, wherein the computer processing system is further configured to determine exemplary angular displacements of incident light for each light intensity measurement from a reference position relative to the field of view."**

Gallagher and Frank render obvious the additional limitations of claim 21 for the reasons stated regarding claim 15. *Supra* Section IV.B.3; Thorpe ¶144.

7. **Claim 22: “The automated method of claim 21, wherein each of the exemplary angular displacements of incident light comprises an observation angle corresponding to one of a plurality of distances of the light source from the road marker.”**

Gallagher and Frank render obvious the additional limitations of claim 22 for the reasons stated regarding claim 15. *Supra* Section IV.B.3; Thorpe ¶145.

C. Ground 3: Gallagher, Schofield, Frank, and ASTM Render Obvious Claims 14 and 20

1. ASTM

ASTM is a standard “under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials” and was “[p]ublished July 1996.” ASTM, 451 n.1. It was included as part of the *1997 Annual Book of ASTM Standards*, Volume 04.03, for Road and Paving Materials and was publicly accessible to persons interested and ordinarily skilled in the art no later than within a few days of July 22, 1997, when it was received at the Library of Congress as a part of the *1997 Annual Book of ASTM Standards*. ASTM, p. i, 451; Ex. 1022, ¶¶16-26. Accordingly, ASTM qualifies as a prior-art printed publication to the ’328 patent under pre-AIA § 102(a)-(b)/AIA § 102(a)(1).

ASTM “covers a type of plowable, retroreflective, raised pavement marker for lane marking and delineation” and specifies minimum values for their “coefficient of (retroreflected) luminous intensity.” ASTM, 451-453; Thorpe ¶¶146-148. Retroreflective markers are classified based on their type (e.g., one-

way or two-way retroreflective markers) and color (e.g., one color or two colors).

ASTM, 452. Marker colors include white, yellow, red, blue, and green. ASTM, 452-453. ASTM specifies a different minimum coefficient of luminous intensity for each color based on particular entrance and observation angles. *Id.* ASTM's Table 1, below, shows those values. ASTM, 453.

TABLE 1 : Coefficient of Luminous Intensity R_i

NOTE—Entrance angle component β_1 and rotation angle ϵ are 0° .

Entrance Angle β_2	Observation Angle α	Minimum Value R_i , mcd/lx				
		White	Yellow	Red	Green	Blue
0°	0.2°	279	167	70	93	26
$+20^\circ/-20^\circ$	0.2°	112	67	28	37	10

Entrance Angle β_2	Observation Angle α	Minimum Value R_i , cd/lc				
		White	Yellow	Red	Green	Blue
0°	0.2°	3.0	1.8	0.75	1.0	0.28
$+20^\circ/-20^\circ$	0.2°	1.2	0.72	0.3	0.4	0.11

ASTM, 453 (Table 1).

In Table 1, entrance angle is “the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker,” and observation angle is “the angle at the reflector between the illumination axis and the observation axis.” ASTM, 452. As in Gallagher, values are specified in units of millicandela per lux (mcd/lux). ASTM, 453 (Table 1); *see* Gallagher, [0067], [0079].

2. ASTM Is Analogous Art

ASTM is analogous art to the '328 patent because it is reasonably pertinent to problems addressed by the '328 patent, including automatically identifying road markers without relying solely on “template matching of shape and color.”

Ex. 1001, 1:39-47; ASTM, 451-454. ASTM discloses relationships between an entrance angle, an observation angle, and a minimum coefficient of luminous intensity value for various colors of raised pavement markers, allowing an automatic system (like Gallagher's) to determine the predetermined minimum reflectivity for a given entrance angle and observation angle. ASTM, 451-454; Thorpe ¶149.

3. **Claim 14: “The automated system of claim 9, wherein the computer processing system is further configured to determine an entrance angle and an observation angle of the road marker as part of the assessment of the discrete location of the road marker within the field of view.”**

Gallagher, Frank, and ASTM render obvious the additional limitations of claim 14. Thorpe ¶¶150-156.

As discussed for Ground 2, claim 15, Gallagher and Frank render obvious the computer processing system being configured to determine an observation angle of the road marker as part of the assessment of the discrete location of the road marker within the field of view. *Supra* Section IV.B.3; Thorpe ¶151. A POSITA would have found it obvious to likewise configure the computer

processing system to determine an entrance angle as part of this assessment to ensure that it has selected the correct “predetermined minimum acceptable reflectance level” for a given road marker to compare to the determined reflectance level. Gallagher, [0067]-[0068].

Gallagher discloses that, to determine whether a road marker meets a “predetermined minimum acceptable reflectance level,” it determines “the reflectance level of the road marker in a value of millicandela per Lux (CIL).” *Id.* ASTM teaches that the minimum reflectance level for a road marker varied depending on both the observation angle *and* entrance angle. ASTM, 452-453; Thorpe ¶152. For example, the minimum coefficient of luminous intensity, another term for the CIL value, for a red road marker is 70 for an observation angle of 0.2 degrees and entrance angle of 0 degrees, but the coefficient of luminous intensity value drops to 28 when the entrance angle changes to 20 degrees. ASTM, 453 (Table 1). Thorpe ¶152; *see* Ex. 1016, 5 (defining “the coefficient of luminous intensity” as “CIL”).

A POSITA would have therefore been motivated to implement Frank’s laser diode that outputs a pulse-modulated floodlight beam and Frank’s determination of the distance and angle to each identified retroreflector to improve Gallagher’s determination of whether a road marker’s reflectivity is “less than the predetermined minimum acceptable reflectance level” by factoring in both the

observation angle and entrance angle for each of its light intensity measurements.

Gallagher, [0067]-[0068]; Thorpe ¶153. Given the variance between minimum reflectivity values between different entrance angles and observation angles, a POSITA would have seen this combination as advantageous to improve Gallagher's accuracy in assessing whether a road marker is satisfactory.

Thorpe ¶153.

A POSITA would have understood that Frank's determination of its angle α , depicted below, is one common way to estimate the entrance angle. Frank, 10:67-11:4, Fig. 2A; Thorpe ¶154.

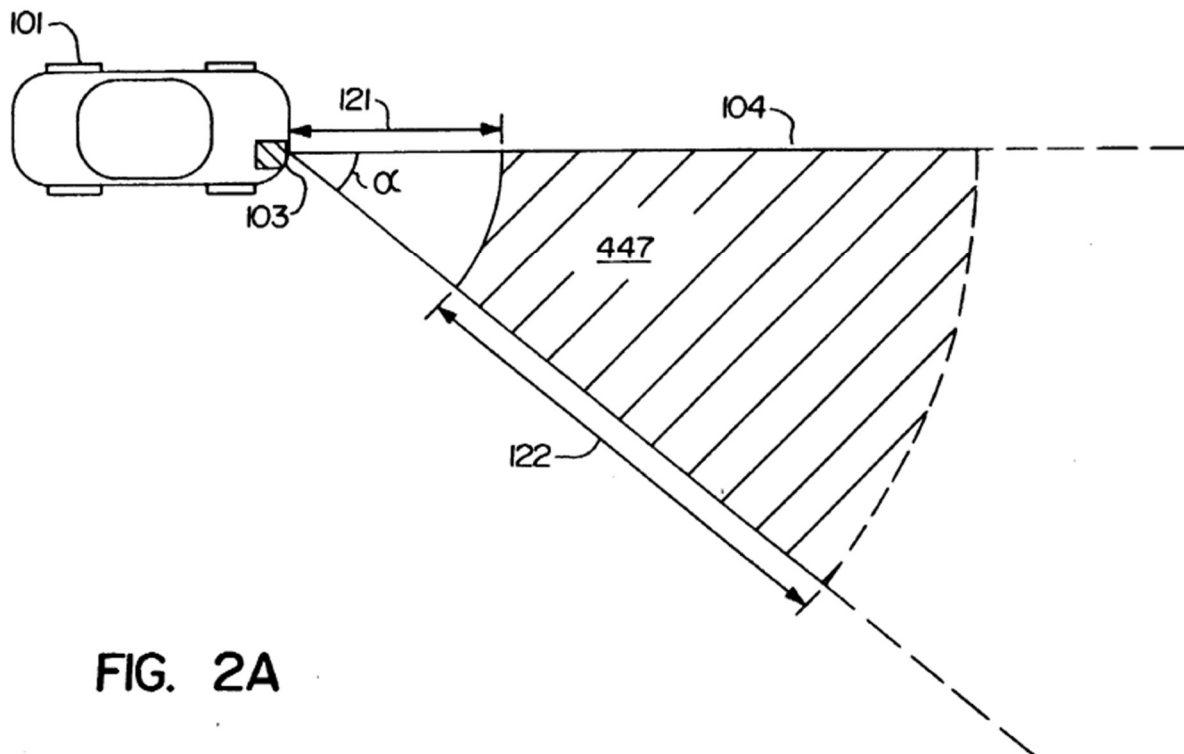


FIG. 2A

Frank, Fig. 2A.

For example, ASTM discloses that the entrance angle is “the angle in the horizontal plane between the direction of incident light and the normal to the leading edge of the marker.” ASTM, 452; Thorpe ¶155. A POSITA would have recognized that, when the road marker is properly mounted, traveling parallel to the lanes of the road would set the vehicle’s axis 104 parallel to the road marker’s normal direction, making Frank’s angle α and the entrance angle equivalent. Thorpe ¶155.

A POSITA would have reasonably expected success for the reasons discussed regarding Ground 2, claim 15. *Supra* Section IV.B.3; Thorpe ¶156. Estimating the entrance angle using Frank’s angle α would have required a POSITA to apply only conventional data-processing techniques to determine an angle based on the light sensor in the array that receives the reflected light to predictably yield an improved reflectivity measuring apparatus that more accurately assesses whether a road marker meets minimum specified levels. Frank, 10:67-11:4, 12:21-39, Fig. 11; Thorpe ¶156.

4. Claim 20: “The automated method of claim 17, wherein the computer processing system is further configured to determine an entrance angle and an observation angle of the road marker.”

Gallagher, Frank, and ASTM render obvious the additional limitations of claim 20 for the reasons discussed regarding claim 14. *Supra* Section IV.C.3; Thorpe ¶157.

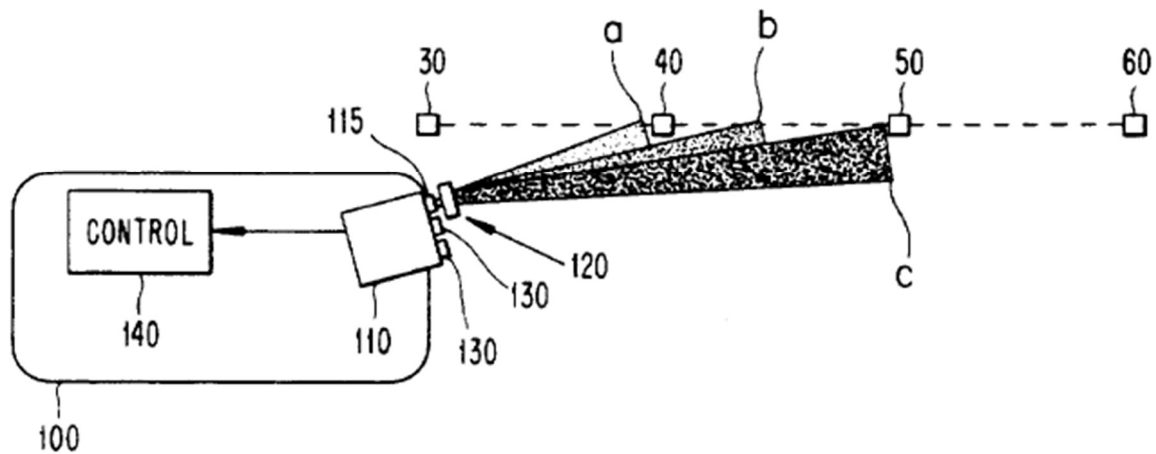
D. Ground 4: Gallagher, Schofield, Leonard, and Popovich Render Obvious Claims 5-7

1. Leonard

Leonard discloses “detecting objects to control a vehicle” using an expanded field of view “to permit plural objects to be detected simultaneously.” Leonard, 1:7-9, 2:8-13; Thorpe ¶¶158-160. Leonard recognized that, to detect “retro-reflector markers located along a path over which a vehicle is to be guided,” “a beam must be generated with a relatively large field of view.” Leonard, 1:19-24.

Leonard discloses splitting the beam into “sub-fields,” where “[s]ub-fields associated with distant objects are set to a greater intensity to ensure reflection of the sub-fields back to the receiver,” and “[s]ub-fields directed to closer objects have a lesser intensity to avoid detection of false objects.” Leonard, 2:8-19. For example, as depicted below, a vehicle includes a diode laser 110 “for generating a beam of light” that is passed through a “transmitting lens 115” and “an additional separating means, such as a grating 120” or a prism. Leonard, 4:62-5:20. Because “the angle of an expected marker location with respect to the vehicle is proportional to the distance of the marker from the vehicle for a vehicle path that is straight,” the intensities of the sub-fields decrease as the angle of the beam relative to the vehicle path increases. Leonard, 3:45-52, 5:43-62, 7:1-3.

Fig. 3



Leonard, Fig. 3.

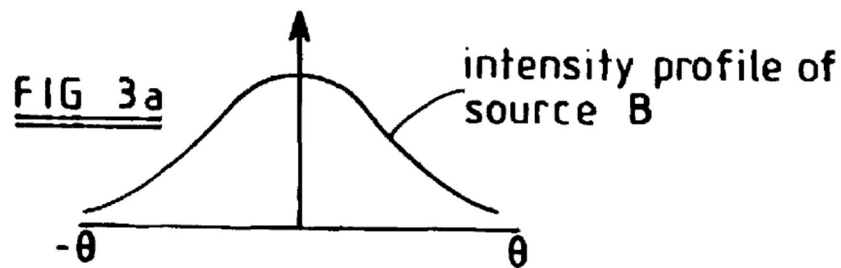
“Each sub-field can be used to detect the distance and angular orientation of any number of objects located within the sub-field” Leonard, 3:18-23, 5:58-62. Leonard discloses that any type of light-detecting element may be used “for receiving the reflected sub-fields from the markers.” Leonard, 8:52-55. Once light is detected, “the detected signals are processed by a controller” “to detect the position of the vehicle relative to the detected objects.” Leonard, 8:52-59.

2. Popovich

Popovich discloses “[a]n optical triangulation tracking system” that generates two divergent beams of light with “a predetermined spatial and angular relationship” that illuminate a space including “at least one reflector.” Popovich, Abstract; Thorpe ¶¶161-163. A light detection device receives the light reflected

by the reflector, and an image processing system determines the reflector's "spatial coordinates" within the space. *Id.*

Popovich's system, similar to Leonard, may use a beam with "a smoothly varying intensity profile." Popovich, 5, 10. For example, Figure 3a, below, depicts the "angular intensity distribution profile" of a light source, where "the 'Y'-axis is intensity and the 'X'-axis is the angle theta with $x=0$ corresponding to the optical axis" of the light source. Popovich, 10.



Popovich, Fig. 3a.

A sensor array measures the intensity of the reflected light. Popovich, 6-8, 10. By determining "the peak of the spot's intensity profile" in the array, "it is possible to define a ray vector that passes through the cent[er] of the retroreflector. Popovich, 6-7. Additionally, Popovich discloses that the "non-uniform light pattern" can be used to determine the position of a retroreflector "merely by analy[z]ing the intensities of reflected light ... and comparing that with an intensity look-up table ... held within computation means." Popovich, 13.

3. Leonard and Popovich Are Analogous Art

Leonard and Popovich are analogous art to the '328 patent because they are in the same field of endeavor, namely, automated object recognition. Ex. 1001, 1:31-32; Leonard, 1:7-9, 5:54-62, 8:52-64; Popovich, 5-7; Thorpe ¶164. Leonard and Popovich are also analogous art to the '328 patent because they are reasonably pertinent to problems addressed by the '328 patent, including automatically identifying objects of interest without relying solely on “template matching of shape and color.” Ex. 1001, 1:39-47; Leonard, 1:7-9, 5:54-62, 8:52-64 (identifying road markers based on “receiving the reflected sub-fields from the markers” using a “light detecting element”); Popovich, 5-7 (identifying the position of a “retroreflective target” by determining the position of the sensor in the sensor array that received the reflected light’s “spot intensity”); Thorpe ¶164.

4. Rationale for Combining Gallagher, Leonard, and Popovich

A POSITA would have found it obvious to implement Leonard’s expanded field of view that includes a light source with sub-fields of different intensities to improve its detection and measuring of the reflectivity of road markers, and would have found it obvious to implement Popovich’s triangulation of a retroreflective object by measuring the angle of light vectors at two known points to determine the location of the road markers detected in the expanded field of view. Thorpe ¶¶165-174.

Gallagher discloses that “[t]he incident angle between the angle of the beam to road level is held constant over any one test,” which requires adjusting the beam between tests “to account for factors such as testing markers 2 around bends and on undulating roads.” Gallagher, [0036]; Thorpe ¶166. A POSITA would have looked to Leonard to expand the field of view with a light source like Leonard’s to avoid needing to adjust the beam angle between tests and to increase the numbers of measurements that Gallagher’s reflectivity measuring apparatus may take for each road marker at any given pass, thereby improving the accuracy of its reflectivity measurements. Thorpe ¶166.

Leonard’s system includes an expanded field of view to identify three “reflectors spaced by a predetermined distance along the vehicle path” at any given time. Leonard, 3:6-10, 3:25-27, 4:62-5:39. It accomplishes this by creating sub-areas that decrease in intensity as the angle deviates from the path of the vehicle. Leonard, 3:45-52, 4:3-13, 4:62-5:22; Thorpe ¶167. “Each sub-field can be used to detect the distance and angular orientation of any number of objects located within the sub-field” Leonard, 5:58-62.

A POSITA would have been motivated to implement Leonard’s teaching of an expanded field of view using a light source whose intensity decreases as the angle relative to the vehicle’s heading increases in Gallagher’s apparatus to simultaneously detect and measure the reflectivity of multiple road markers.

Thorpe ¶168. A POSITA would have seen this as advantageous to avoid the need to adjust the light source's "incident angle" between measurements "to account for factors such as testing markers 2 around bends and on undulating roads."

Gallagher, [0036]; Thorpe ¶168. Increasing the field of view would have "ensur[ed] the detection of the objects," and thus the measurements of their reflectivity, regardless of the road slope or curvature. Leonard, 1:22-24; Thorpe ¶168. Additionally, expanding the field of view would have advantageously allowed Gallagher's apparatus to increase the number of reflectivity measurements taken because the reflectors would be in the field of view of the sensor array module longer, increasing the likelihood of an accurate measurement. Thorpe ¶168.

Gallagher also suggests implementing Leonard's expanded field of view because it discloses that increasing the "width of [the] beam may be desirable for testing markers 2 that are spaced apart on the road." Gallagher, [0043]; Thorpe ¶169. Implementing Leonard's light source with varying intensity and expanded field of view would have improved Gallagher's apparatus by allowing for simultaneous reflectivity measurements of multiple road markers located both close to and far away from the vehicle. Thorpe ¶169.

Gallagher discloses determining "the location of each road marking" that it measures based on the location of the vehicle (e.g., using a GPS interface).

Gallagher, [0048], [0063]-[0064]. By increasing the field of view to simultaneously measure the reflectivity of multiple road markers at varying distances, a POSITA would have looked to Popovich for a way to identify the location of each road marker measured. Thorpe ¶170.

Popovich discloses a technique for triangulating a retroreflector in space using a light detection device that receives light from two beams with a known spacing between them. Popovich, 1-2, 5-7; Thorpe ¶171. Popovich's light detection device is an array of photodetectors "whose responses are thresholded such that a binary image consisting of a single spot moving against a black background is formed." Popovich, 6. By measuring the peak intensity's location within the array, Popovich's system defines "a ray vector that passes through the cent[er] of the retroreflector." Popovich, 6-7; Thorpe ¶171. It then obtains "the position of the target retroreflector 3" by "computing the intercept of the ray vectors" for two measurements. Popovich, 7.

A POSITA would have been motivated to implement Popovich's triangulation in Gallagher's modified apparatus with the expanded field of view to improve the location accuracy for each road marker. Thorpe ¶172. Gallagher's apparatus samples "road marking reflectance level data at frequent intervals" and includes "a GPS interface 15 [that] can be used to pinpoint the position of the vehicle and/or markers 2 as measurements are being taken." Gallagher, [0047]-

[0048]. Thorpe ¶172. Determining the angle of the road marker relative to the light source at multiple points and the GPS location of each measurement would have allowed Gallagher's apparatus to "comput[e] the intercept of the ray vectors" from each measurement and determine "the position of" each identified road marker. Gallagher, [0047]-[0048]; Popovich, 7; Thorpe ¶172. A POSITA would have implemented this triangulation technique to properly tag the location of any road markers whose reflectivity is "less than the predetermined minimum acceptable reflectance level." Gallagher, [0068]; Thorpe ¶172.

A POSITA would have reasonably expected success in combining Gallagher, Leonard, and Popovich because Gallagher already discloses modifying the field of view's size, and Leonard teaches an apparatus that identifies the same types of road markers as Gallagher. Gallagher, [0037]; Leonard, 1:7-9, 5:54-62, 8:52-64; Thorpe ¶173. Accordingly, modifying Gallagher to implement Leonard's teaching of an expanded field of view with varying light-source intensity based on the angle would have merely combined familiar elements according to known methods to predictably yield an apparatus that concurrently identifies and measures the reflectivity of multiple road markers. Thorpe ¶173.

Additionally, Gallagher already discloses a GPS interface for identifying the vehicle location and taking multiple measurements, so further implementing Popovich's triangulation to determine the location of the road markers would have

required a POSITA to apply only conventional techniques for determining the reflected angle off the road marker and each measurement location and using basic trigonometry to triangulate the road marker's location relative to the vehicle. Thorpe ¶174. Indeed, Leonard discloses using “[a]ny type of light detecting element,” and Popovich discloses using both two-dimensional and linear sensor arrays to implement its triangulation technique, leading a POSITA to reasonably expect that its sensor array would work to implement this technique. Leonard, 8:54-55; Popovich, 8; Thorpe ¶174. And Gallagher discloses that “a wide variety of light sources can be suitable for this form of testing,” leading a POSITA to reasonably expect that a light source with a wide field of view would work for this application. Gallagher, [0037]; Thorpe ¶174.

5. **Claim 5: “The automated system of claim 1, wherein the computer processing system is configured to determine the location of the road marker using the light intensity values for the reflective surface by using a location and heading of the active sensor and a location of the object of interest to determine a light vector emanating from the light source responsible for one of the light intensity values and comparing the light vector to one of a plurality of predetermined vectors based on a light source angle characterization.”**

Gallagher, Leonard, and Popovich render obvious the additional limitations of claim 5. Thorpe ¶¶175-179.

Gallagher's computer processing system determines the location of each road marker tested. *Supra* Section IV.A.11.g (Ground 1, [1H]); Thorpe ¶176. This

location determination uses “a GPS interface 15 ... to pinpoint the position of the vehicle and/or markers 2 as measurements are being taken.” Gallagher [0048].

Because the light source is in a fixed location on Gallagher’s vehicle, this GPS position of the vehicle corresponds to the location of the active sensor.

Thorpe ¶176. Accordingly, a POSITA would have recognized that additional steps would have been necessary to also determine the location of the markers. *Id.*

The combination of Leonard and Popovich discloses the known techniques for determining the location of markers detected by a moving vehicle. Leonard discloses an expanded field of view that identifies multiple reflective road markers. Leonard, 4:62-5:62; Thorpe ¶177. This expanded field of view includes sub-fields of varying intensity that “can be used to detect the distance and angular orientation of any number of objects located within the sub-field.” Leonard, 5:43-62. Popovich similarly discloses a light source having “a non-uniform symmetrical intensity profile,” a “light detection means” that “measure[s] the intensity of light incident thereon,” and an image processing system that “determine[s] the trajectory of incident light from the intensities received.” Popovich, 2-3; Thorpe ¶177. By measuring the location of the intensity peak within the sensor array, the image processing system “define[s] a ray vector that passes through the cent[er] of the retroreflector.” Popovich, 6-7; Thorpe ¶177. A POSITA would have understood this to disclose using a heading of the active sensor and a location of the object of

interest to determine a light vector emanating from the light source responsible for one of the light intensity values because, due to the speed of light, the angle of the incident light on the light sensor array corresponds to the angle of the light vector emanating from the light source relative to the light-source heading that is responsible for one of the light intensity values. Thorpe ¶177.

Because the light-source intensity varies relative to its heading, a POSITA would have found it obvious to compare the determined light vector to one of a plurality of predetermined vectors based on a light source angle characterization. Thorpe ¶178. Gallagher discloses selecting, from the light intensity values, “which reflectance levels indicate a road marker.” Gallagher, [0066]. But it was known that “[t]he received intensity will be a function of the angular bearing with respect to” the light source “and the distance of the retroreflector 3 from each light source.” Popovich, 10; Thorpe ¶178. Accordingly, a POSITA would have been motivated to compare the determined light vector to the known “angular intensity distribution profile” for the light source to determine whether a particular light intensity value received at the determined angle corresponds to a road marker. Thorpe ¶178.

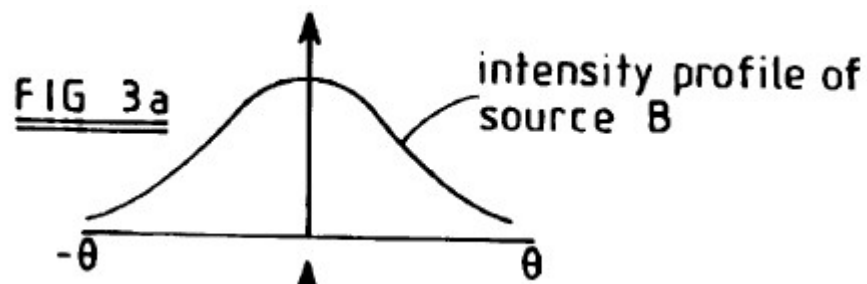
As discussed in Section IV.D.4, a POSITA would have been motivated to combine Gallagher, Leonard, and Popovich, and would have reasonably expected success in doing so, to use the light source’s position (as determined by the GPS

interface) and the angle of the road marker relative to the light source's heading (as determined through analysis of the light intensity values in the light sensor array) at multiple locations to determine the location of the road marker using the light intensity values through triangulation. Thorpe ¶179.

6. **Claim 6: “The automated system of claim 5, wherein the light source angle characterization is a look-up-table that relates an angular displacement from a normal vector for the light source to a light intensity for the light vector associated with the reflective surface.”**

Gallagher, Leonard, and Popovich render obvious the additional limitations of claim 6. Thorpe ¶¶180-182.

As discussed for claim 5, a POSITA would have been motivated to compare the determined light vector to the known “angular intensity distribution profile” for the light source to determine whether a particular light intensity value received at the determined angle corresponds to a road marker. *Supra* Section IV.D.5; Popovich, 10; Thorpe ¶181. Popovich discloses the graph below that relates an angular displacement from a normal vector for the light source to a light intensity for the light vector associated with the reflective surface. Popovich, 10, Fig. 3a.



Popovich, Fig. 3a.

A POSITA would have been motivated to include this intensity profile in a look-up table within the computer processing system because such look-up tables were well-known ways to compare and identify related data. Thorpe ¶182. Popovich already discloses determining the position of a retroreflector illuminated by a “non-uniform light pattern” “by analy[z]ing the intensities of reflected light 19, 23 and comparing that with an intensity look-up table 710 held within computation means.” Popovich, 13; Thorpe ¶182. Accordingly, implementing the comparison of the light source angle characterization as a look-up-table would have combined familiar elements according to known methods to predictably yield a quick and efficient way to identify the light-source intensity for a given angle. Thorpe ¶182.

7. **Claim 7: “The automated system of claim 5, further comprising a global positioning satellite (GPS) unit that determines a location of the vehicle operably coupled to the computer processing system, wherein the location of the vehicle is used in determining the location of the road marker.”**

As discussed for claim 5, Gallagher discloses a “GPS interface 15” (GPS unit) that “can be used to pinpoint the position of the vehicle” and is used in determining the location of the road marker. Gallagher, [0048]; *supra* Section IV.D.5; Thorpe ¶183.

V. DISCRETIONARY DENIAL IS NOT WARRANTED

A. Discretionary Denial Is Inappropriate Under 35 U.S.C. § 314(a) and *Fintiv*

At this time, no factors articulated in *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 at 5-6 (PTAB Mar. 20, 2020) (precedential), weigh in favor of noninstitution under 35 U.S.C. § 314(a) because no trial date has been set in the litigation.

B. Discretionary Denial Is Inappropriate Under 35 U.S.C. § 325(d)

Noninstitution under § 325(d) would also be improper based on the factors in *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 at 17-18 (Dec. 15, 2017). Schofield, Frank, ASTM, Leonard, and Popovich were never considered during prosecution. While the '328 patent cites Gallagher on its face, the Examiner never applied Gallagher, one reference of well over one hundred cited during prosecution, in any rejection for the '328 patent. *See* Ex. 1001, Item (56) (References Cited); *see generally* Ex. 1002. Indeed, the Examiner did not apply *any* art during the prosecution, and the claims differ from those found in earlier related patents and never received a double-patenting rejection.

VI. MANDATORY NOTICES

A. Real Party-in-Interest Under 37 C.F.R. § 42.8(b)(1)

The real party-in-interest for this Petition is Mobileye Global, Inc.

B. Related Matters Under 37 C.F.R. § 42.8(b)(2)

To the best knowledge of Petitioner, the '328 patent is involved in the following district court litigations:

Name	Number	Court	Filed
<i>Facet Tech. Corp. v. Mobileye Glob., Inc.</i>	2:24-cv-00058	E.D. Tex.	Jan. 26, 2024
<i>Facet Tech. Corp. v. Gen. Motors LLC</i>	2:24-cv-00035	E.D. Tex.	Jan. 22, 2024
<i>Facet Tech. Corp. v. Here Glob. B.V.</i>	2:24-cv-00269	E.D. Tex.	Apr. 22, 2024
<i>Facet Tech. Corp. v. TomTom Int'l B.V. et al.</i>	1:24-cv-00111	D.N.H.	Apr. 23, 2024

Petitioner is also concurrently filing another petition for IPR challenging the claims of U.S. Patent No. 9,335,255, a patent related to the '328 patent. The '328 patent is also the subject of an *ex parte* reexamination request, which was filed as Application No. 90/019,546 by Unified Patents, LLC, on June 20, 2024.

C. Lead and Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)

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D. Service Information Under 37 C.F.R. § 42.8(b)(4)

Please address all correspondence to counsel at the addresses above.

Petitioner also consents to electronic service by e-mail.

VII. GROUNDS FOR STANDING

Petitioner certifies that the '328 patent is available for IPR and that
Petitioner is not barred or estopped from requesting review.

VIII. CONCLUSION

For the foregoing reasons, claims 1-22 should be canceled.

Dated: August 1, 2024

By: /Cory C. Bell/
Cory C. Bell, Lead Counsel
Reg. No. 75,096

CERTIFICATE OF COMPLIANCE

The undersigned hereby certifies that the foregoing **Petition for *Inter Partes* Review** contains 13,967 words, excluding those portions identified in 37 C.F.R. § 42.24(a), as measured by the word-processing system used to prepare this paper.

/Cory C. Bell/
Cory C. Bell, Lead Counsel
Reg. No. 75,096

CERTIFICATE OF SERVICE

The undersigned certifies that, in accordance with 37 C.F.R. §§ 42.6(e) and 42.105, the **Petition for *Inter Partes* Review of U.S. Patent No. 9,671,328, the associated Power of Attorney, and Exhibits 1001-1017, and 1020-1022** were served via FedEx Priority Overnight on the correspondence address of record indicated in the Patent Office's Patent Center system for U.S. Patent No. 9,671,328:

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3000 K Street N.W.
Suite 600
Washington, DC 20007-5109

Dated: August 1, 2024

By: /Daniel E. Doku/
Daniel E. Doku
Litigation Legal Assistant
Finnegan, Henderson, Farabow,
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