

Petitioner's Demonstratives

**Mobileye Global, Inc., and
ZF Active Safety and Electronics US LLC**

v.

Facet Technology Corporation

IPR2024-01110

IPR2024-01111

December 5, 2025

MOBILEYE ET AL. EXHIBIT 1036

MOBILEYE ET AL. v. FACET

IPR2024-01110

IPR2024-01111
U.S. Patent No. 9,671,328

U.S. Patent No. 9,671,328

U.S. Patent No. 9,671,328 “System and Assessment of Reflective Objects Along a Roadway”



(12) **United States Patent**
Retterath et al.

(10) **Patent No.: US 9,671,328 B2**
(45) **Date of Patent: Jun. 6, 2017**

(54) **SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY**

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(73) Assignee: **Facet Technology Corp.**, Eden Prairie, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/148,722**

(22) Filed: **May 6, 2016**

(65) **Prior Publication Data**
US 2016/0377529 A1 Dec. 29, 2016

Related U.S. Application Data

(60) Continuation of application No. 14/512,735, filed on Oct. 13, 2014, now Pat. No. 9,334,255, which is a (Continued)

(51) **Int. Cl.**
G01N 21/00 (2006.01)
G01N 21/25 (2006.01)
(Continued)

(52) **U.S. Cl.**
G01N 21/251 (2013.01); **G01N 21/55** (2013.01); **G01N 21/84** (2013.01); **G01S 17/06** (2013.01);
(Continued)

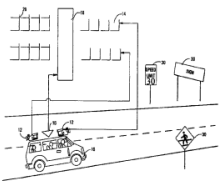
(58) **Field of Classification Search**
CPC — G02B 27/0172; G02B 2027/0178; G02B 2027/014; G02B 2027/0138;
(Continued)

(56) **References Cited**
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Dominant Color Transform and Circular Pattern Vector for Traffic Sign Detection and Recognition, Jung Hak and Tae Young Choi, IECE Transaction Fundamentals, vol. E81-A, No. 6, pp. 1128-1135, Jun. 1998.
(Continued)

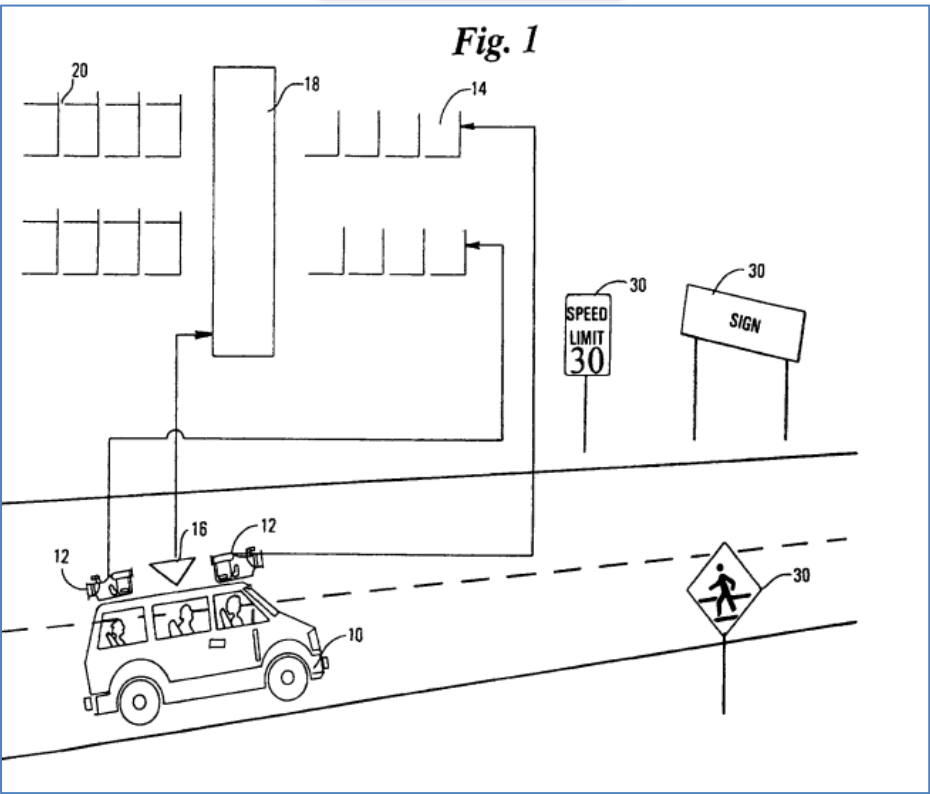
ABSTRACT
(57)
A system for classifying different types of sheeting materials of road signs depicted in a videostream compares estimated retroreflectivity values against known minimum retroreflectivity values for each of a plurality of colors. Once a road sign has been identified in the videostream, the frames associated with that road sign are analyzed to determine each of a plurality of colors present on the road sign. An estimated retroreflectivity for each of the plurality of colors present on the road sign is then determined. By comparing the estimated retroreflectivity for each of the plurality of colors against known minimum retroreflectivity values for the corresponding color for different types of sheeting materials, an accurate determination of the classification of the sheeting material of the road sign is established. Preferably, certain conditions of gross failure of the sheeting material are filtered out before classification of the sheeting material is determined.

22 Claims, 18 Drawing Sheets



Page 1 of 32 MOBILEYE EXHIBIT 1001

The '328 Patent



'328 Patent (Ex. 1001), Fig. 1

Remaining Unpatentability Grounds

Ground	Claims	Obviousness Basis
1	1-4, 8-13, ~~17-18~~	Gallagher and Schofield
2	15-16, ~~19, 21-22~~	Gallager, Schofield, and Frank
3	14, ~~20~~	Gallagher, Schofield, Frank, and ASTM
4	5-7	Gallagher, Schofield, Leonard, and Popovich

Pet. 2

- Claims 1-16 remain pending after Patent Owner's disclaimer

Prior art: Gallagher (Ex. 1005)

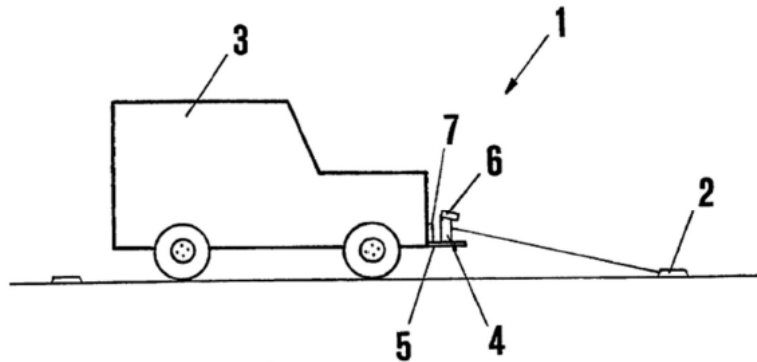
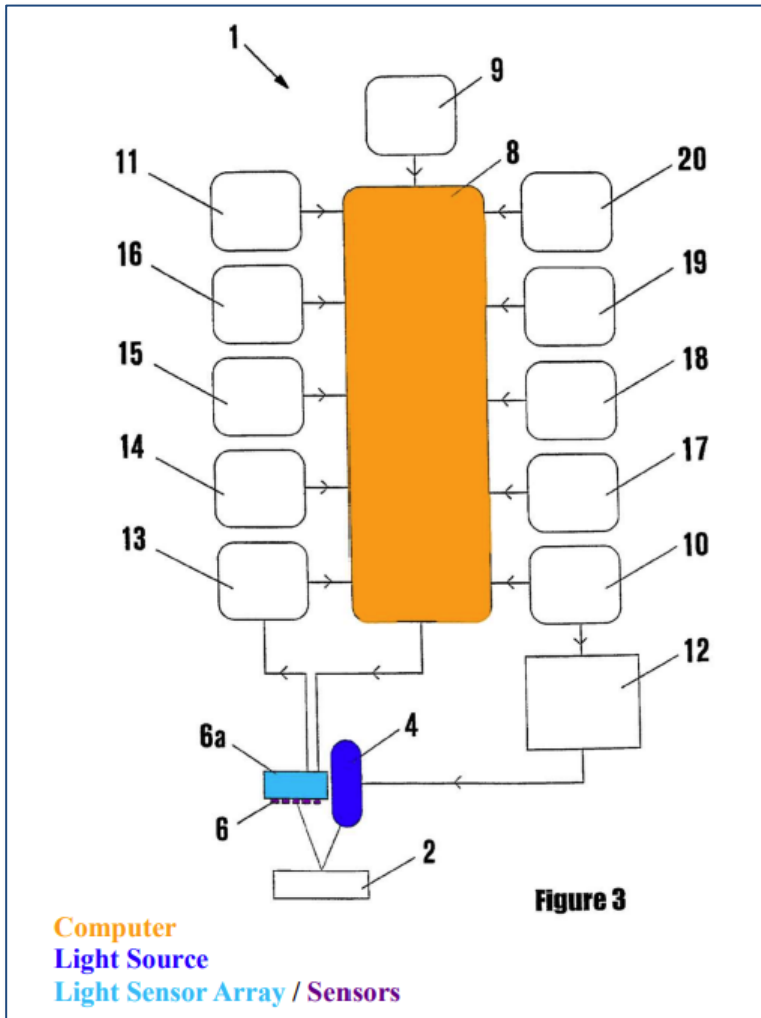


Figure 1

[0032] The apparatus 1 is designed to measure the reflectivity of road markings 2 when in transit. The apparatus 1 is mounted on a moveable platform in the form of a vehicle 3. The apparatus 1 can obtain reflectivity measurements, inter alia, with the vehicle 3 travelling at speeds of up to about 100 kph. This means that testing can be carried out alongside other vehicles on a road without being an inconvenience or impediment to the normal flow of traffic.

[0033] The apparatus 1 can test the reflectivity of a wide variety of reflective road markings and road markers such as, for example, road signs and posts, reflective painted lines whether continuous or broken, and more particularly raised pavement markers. For simplicity the description of the preferred embodiment of the invention will be limited to raised pavement markers 2 (referred to herein as “markers”). However, it will be appreciated by those skilled in the art that the apparatus 1 can be adapted to measure other types of reflective markings on or adjacent the road.

Prior art: Gallagher (Ex. 1005)



[0038] A light sensor 6 detects the reflected light from a marker 2. In this embodiment sensor arrays containing a plurality of sensors, generally five or ten, are advantageously aligned in an encased module 6a to increase the field of view of the apparatus 1. The module 6a is adjustable to increase the accuracy of the measurements.

[0045] The processing means is in the form of a computer 8 programmed by a computer program 9 to carry out a method of testing the integrity of road markings according to an aspect of the invention.

[0046] In operation, an operator in the vehicle 3 initiates the measurement process by sending a signal via the computer 8 to activate the light control relay 10. This is conveniently achieved by using a control box 11 located by the operator in the vehicle 3. The relay 10 switches power from the power supply 12 to the light source 4. The light source 4 subsequently illuminates a reflective surface of a marker 2 and the reflected light is detected by one or a number of the light sensors 6 in the module 6a which has been aligned to detect light from a particular area of road.

Prior art: Schofield (Ex. 1006)

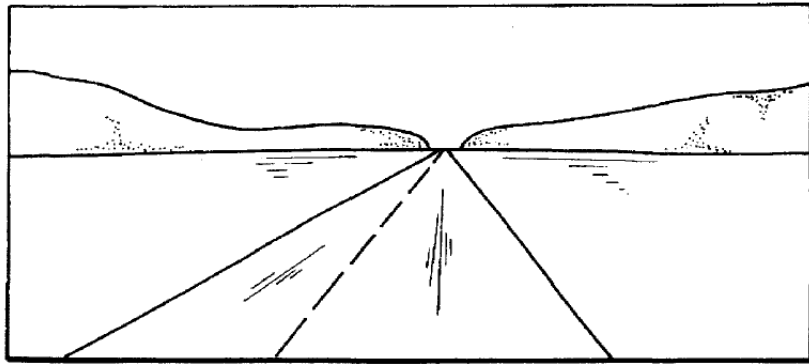


FIG. 11a

Pet. 34-38 (discussing Schofield (Ex. 1006), and Fig. 11a)

Pattern recognition may be used to further assist in the detection of headlights, taillights, and other objects of interest. Pattern recognition identifies objects of interest based upon their shape, reflectivity, luminance, and spectral characteristics. For example, the fact that headlights and taillights usually occur in pairs could be used to assist in qualifying or disqualifying objects as headlights and taillights. By looking for a triad pattern, including the center high-mounted stoplight required on the rear of vehicles, stoplight recognition can be enhanced. Furthermore, object recognition can be enhanced by comparing identified objects over successive frames. This temporal processing can yield information on object motion and can be used to assist in qualifying or disqualifying objects of interest.

Schofield (Ex. 1006), 10:66-11:12

The invention may be utilized to identify particular traffic signs by their spectral signature as well as their geometric organization. For example, red octagons may be identified as stop signs, yellow triangles as caution signs, and the like.

Schofield (Ex. 1006), 12:1-4

Issue 1:
**The Gallagher-Schofield Combination Performs All
Claimed Functions of the Computer Processing
System**

The Claimed Functions of the Computer Processing System

1. 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:

- an image capture system that captures images within a field of view along the roadway;

- an active light sensor including:

 - a light source that illuminates an area along the roadway; and

 - a light sensor that measures light intensity values within at least a portion of the area illuminated by the light source; and

- 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:

 - determine whether the object of interest includes a reflective surface based on the light intensity values;

 - determine whether the reflective surface is a road marker based on an assessment of the reflective surface; and

 - determine a location of the road marker.

'328 Patent (Ex. 1001), claim 1

9. An automated system for assessing reflective surfaces disposed along a roadway comprising:

- 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:

 - a light source to illuminate an area that includes the at least one reflective surface; and

 - 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

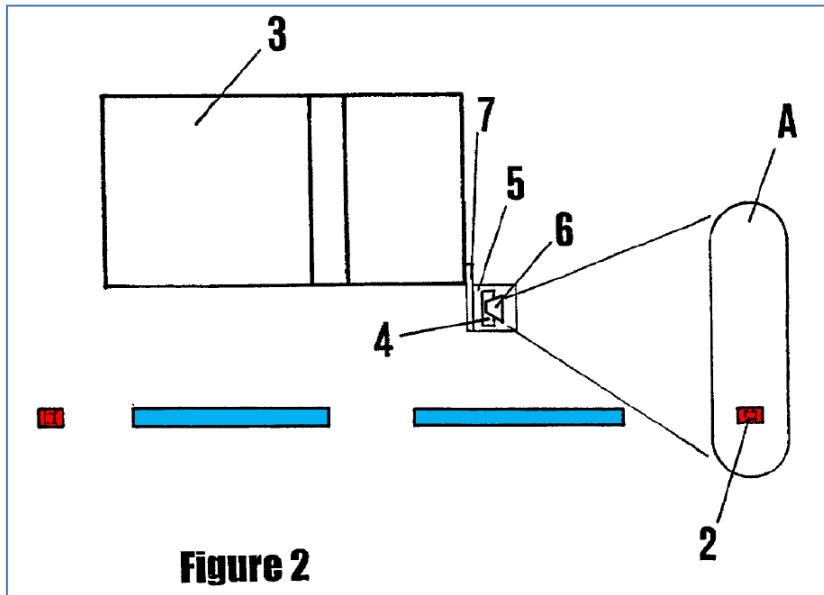
- a computer processing system operably connected to the active light sensor and configured to detect objects of interest within the field of view and for each object of interest:

 - 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

 - 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.

'328 Patent (Ex. 1001), claim 9

Gallagher's computer processing system



Thorpe Suppl. Decl. (Ex. 1030), ¶28.

28. To illustrate, I provide the annotated Figure 2 from Gallagher, below. Gallagher's Figure 2 depicts a vehicle 3 traveling along a roadway adjacent to road markings that include raised pavement markers highlighted in red and painted lines highlighted in light blue. Gallagher, [0033], FIG. 2. Gallagher discloses that both the painted lines and the raised pavement markings may be reflective and that its apparatus may "test the reflectivity" of both. Gallagher, [0033]. As the vehicle travels along this roadway, Gallagher's light sensor array and computer create a representation of the reflected light intensity values one row at a time like a push broom. In doing so, Gallagher's system measures light intensity values from background areas of the road, from areas of the road including painted lines, and from areas of the road including raised pavement markings.

Gallagher detects objects of interest and determines whether each object has a reflective surface

Gallagher detects objects of interest for providing driver with a visual indicator

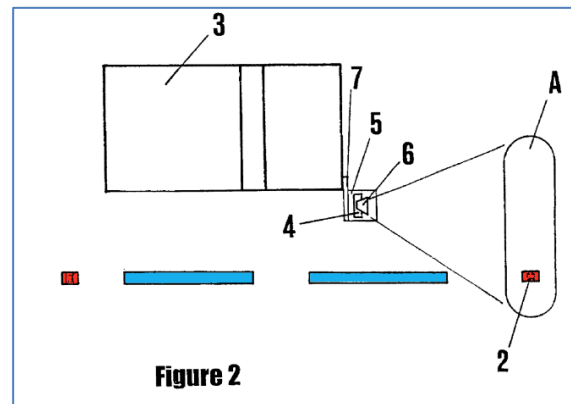
[0010] Preferably the apparatus further comprising an audio and/or visual means to provide an indication of the location of the said road markings relative to the vehicle.

[0060] Process step d. involves determining the vehicle position on the road and providing an audio and/or visual indicator means for the operator of the vehicle 3. This enables the operator to maintain the vehicle 3 in a proper position on the road to allow the apparatus 1 to obtain reflectivity measurements. As each of the five light sensors 6 covers a section of the area A and data from each light sensor is received showing the reflectance levels across area A of the road, then given that background reflectance levels on non road marking sections of the road are low and road markers 2 are relatively high, the computer program can detect which light sensor 6 is reading the highest reflectance reading and to provide the operator with that information.

Gallagher separately determines whether each object has a reflective surface

[0065] Process step f. involves determining the background reflectance level on the road and establishing non-marker reflectance levels.

[0066] Process step g. involves selecting, from data obtained in step a., which reflectance levels indicate a road marker. In the case of road markers the peak responses sensed are determined as the highly reflective surfaces of a road marker.



Gallagher determines the location of reflective objects

[0063] Process step e. involves getting data from the vehicle gearbox revolution sensor 14 and determining the distance travelled from the start position of the road marking test so as to determine the location of each road marking.

[0064] This information is used to tag or identify the road markers tested along a stretch of road.

[0048] Location means for determining the location of the markers 2 is also obtained to allow identification of each marker 2 being tested. A gearbox revolution sensor 14 is used to obtain a measurement of the speed of the vehicle 3 and the distance travelled from a reference point. Alternatively a GPS interface 15 can be used to pinpoint the position of the vehicle and/or markers 2 as measurements are being taken.

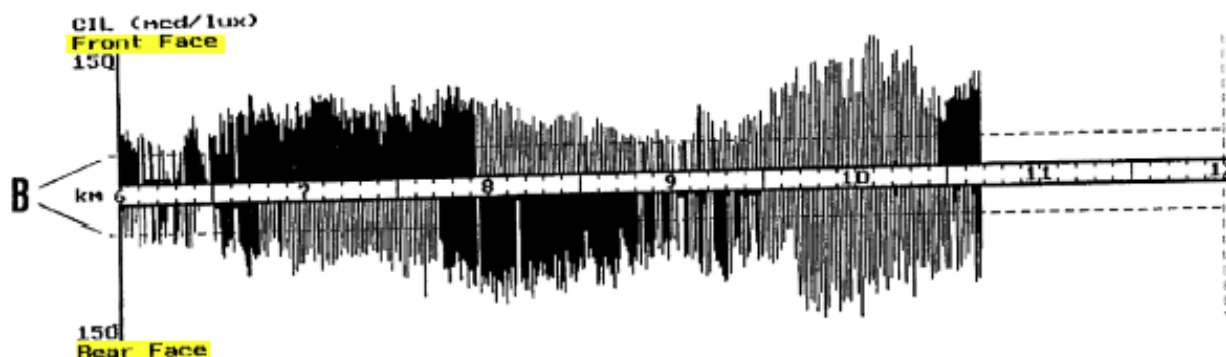


Figure 5

Pet'r Reply, 14-15 (discussing Gallagher (Ex. 1005), Fig. 5)

Gallagher (Ex. 1005), [0063]-[0064], [0048], Fig. 5; Pet. 23-24, 41; Thorpe Suppl. Decl. (Ex. 1030), ¶31; Pet'r Reply, 14-15

Issue 2: Simultaneous Detection & Determination

Standard for Requiring Particular Sequence



Claimed steps need not be performed in a particular order unless either: (1) the claim language, “as a matter of logic or grammar,” requires a particular order, or (2) the specification “directly or implicitly requires such a narrow construction.”

See Altiris, Inc. v. Symantec Corp., 318 F.3d 1363, 1369-70 (Fed. Cir. 2003)

Claim language permits performing detection and determining concurrently

1. 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:

- an image capture system that captures images within a field of view along the roadway;

- an active light sensor including:

 - a light source that illuminates an area along the roadway; and

 - a light sensor that measures light intensity values within at least a portion of the area illuminated by the light source; and

- 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:

 - determine whether the object of interest includes a reflective surface based on the light intensity values;

 - determine whether the reflective surface is a road marker based on an assessment of the reflective surface; and

 - determine a location of the road marker.

'328 Patent (Ex. 1001), claim 1

9. An automated system for assessing reflective surfaces disposed along a roadway comprising:

- 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:

 - a light source to illuminate an area that includes the at least one reflective surface; and

 - 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

- 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:

 - 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

 - 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.

'328 Patent (Ex. 1001), claim 9

The Board Preliminarily Determined that Gallagher Discloses Simultaneously Detecting and Determining

Institution Decision

However, “ordinarily in process claims steps taken concurrently are the equivalent of steps taken successively.” *In re White*, 39 F.2d 974, 975 (CCPA 1930); *see also Cybersettle*, 243 F. App’x. at 609 (finding “the step of calculating the differences between demands and offers can occur concurrently with the [next enumerated step of] receipt of multiple demands and offers”). This is especially true here, given that the recitations at issue are functional language in an apparatus (system) claim. We agree with Petitioner that, on this preliminary record, it appears that Gallagher’s system simultaneously performs the steps of detecting objects of interest and determining whether the objects of interest include at least one light intensity value associated with a reflective surface of a road marker. *See* Ex. 1005 ¶¶ 65–66 (discussing the computer processing the measured reflectance data and determining which reflectance levels across test area A indicate the presence of road markers). We further agree with Petitioner that the

Paper 14 at 29

Gallagher

[0065] Process step f. involves determining the background reflectance level on the road and establishing non-marker reflectance levels.

[0066] Process step g. involves selecting, from data obtained in step a., which reflectance levels indicate a road marker. In the case of road markers the peak responses sensed are determined as the highly reflective surfaces of a road marker.

Gallagher (Ex. 1005), [0065]-[0066]

Paper 14 at 29; Gallagher (Ex. 1005), [0065]-[0066]; Pet. 20-23, 39-40; Pet’r Reply, 10-16; Thorpe Suppl. Decl. (Ex. 1030), ¶¶ 29-30

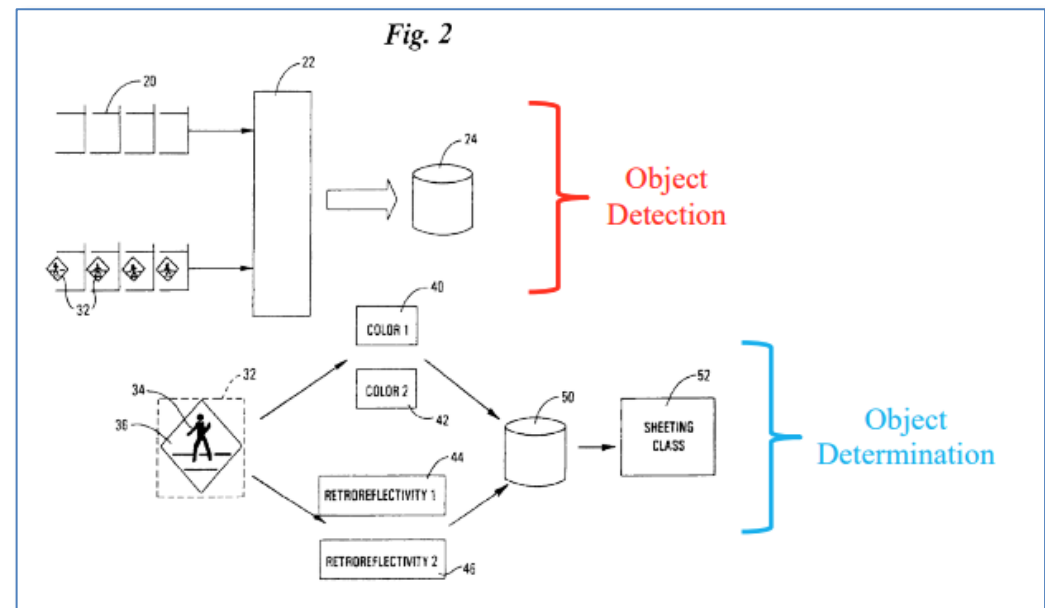
The specification supports Petitioner's interpretation

Either concurrent with or subsequent to the identification of road signs 30 and generation of asset management database 24, the computer processor 22 evaluates that portion 32 of each video frame or image that depicts a road sign 30 to determine a set of color values 40, 42 for each of a plurality of colors on the road sign 32. A retroreflectivity value is generated for each color portion 34, 36 on each frame of the tagged videostream 20 containing the road sign 30 that represents a different color value 40, 42. Preferably, the values for retroreflectivity are determined by measuring the intensity of the signal for each color portion 34, 36. These values are then analyzed over the number of frames containing each color portion 34, 36 to arrive at the maximum retroreflectivity value 44, 46 that corresponds to the color value 40, 42 for each color portion 34, 36 of the road sign 30. These maximum retroreflectivity values 44, 46 will

'328 Patent (Ex. 1001), 5:52-67

Preferably, the computer processor 450 correlates the portion of an image frame of the digital imagery stream 290 with a similar portion of the intensity frame 420 containing the object of interest 460.

'328 Patent (Ex. 1001), 8:40-43



'328 Patent (Ex. 1001), Fig. 2 (annotated)

Ex. 1001, Fig. 2, 5:52-67, 8:40-43; Pet'r Reply, 2, 4-7

Patent Owner's improperly attempts to rewrite the claim language

The appropriate construction for each of these limitations requires that the “determin[ing]” steps be performed on “object[s] of interest” which have already been previously “detect[ed]” in the “detect object of interest” step. Additionally, the “detect” and “determine” steps cannot be simultaneously satisfied by the same act being performed on the same particular object of interest.

POR, 14



Where “the claim language does not tie” the steps together, such as by stating that one step is based on another step, the claim language does not require the steps to be performed in the order written.

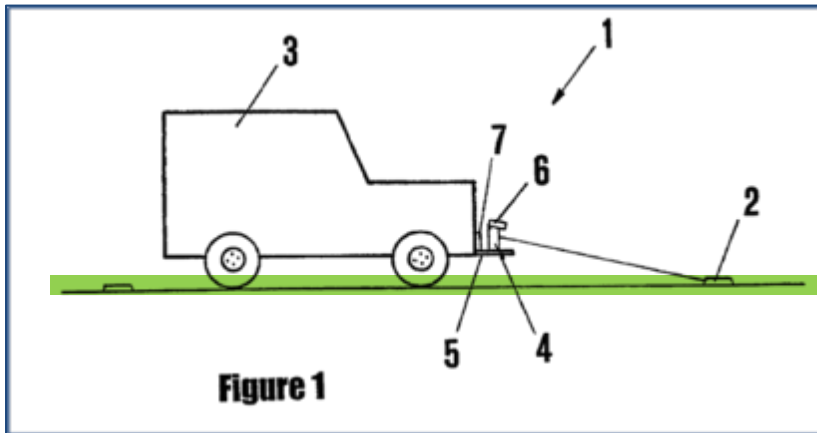
See Sunoco Partners Mktg. & Terminals L.P. v. U.S. Venture, Inc., 32 F.4th 1161, 1176-77 (Fed. Cir. 2022)

POR, 14; Pet'r Reply, 2-4

Issue 3: Motivations to Combine

Motivation to Combine Gallagher and Schofield (Ground 1)

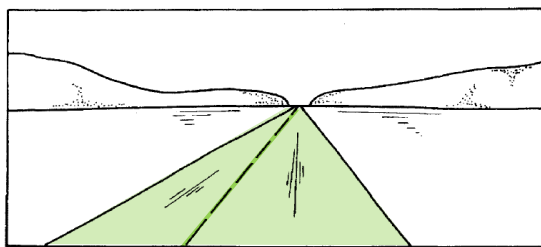
Gallagher and Schofield Detects Road Markers and Intensity Values



Gallagher (Ex. 1005), Fig. 1

Pattern recognition may be used to further assist in the detection of headlights, taillights, and other objects of interest. Pattern recognition identifies objects of interest based upon their shape, reflectivity, luminance, and spectral characteristics. For example, the fact that headlights and taillights usually occur in pairs could be used to assist in qualifying or disqualifying objects as headlights and taillights. By looking for a triad pattern, including the center high-mounted stoplight required on the rear of vehicles, stoplight recognition can be enhanced. Furthermore, object recognition can be enhanced by comparing identified objects over successive frames. This temporal processing can yield information on object motion and can be used to assist in qualifying or disqualifying objects of interest.

Schofield (Ex. 1006), 10:66-11:12



Schofield (Ex. 1006), Fig. 11a

Patent Owner incorrectly argues that the combination would not work

Moreover, the few details that the Petition does provide as to the proposed combination demonstrates that a POSITA would consider it unworkable as of the 2001 priority date of the '328 Patent. In particular, the combination of Gallagher's photodiode peak-sensing approach with Schofield's camera-based techniques would require "sensor fusion." Ex. 2023, ¶93. Sensor fusion is especially difficult here because the sensors provide very different type of information. *Id.*, ¶94. Moreover,

POR, 34-35



38. I also disagree that the need for sensor fusion would have made the combination unworkable. Ex. 2023, ¶¶ 93-96. As I stated in my deposition, object detection using sensor fusion was well known and dated based to at least 1972. I personally worked on a vehicle that incorporated data from a camera and a laser rangefinder to detect objects from a moving vehicle well before the earliest claimed priority date. A person of ordinary skill in the art would have known exactly how to implement Schofield's pattern recognition using data from multiple sensors, particularly because Schofield's camera and Gallagher's sensor array each provide several pieces of information that Schofield teaches is helpful to detect objects of interest. Schofield, 10:66-11:12.

Thorpe Suppl. Decl. (Ex. 1030), ¶ 38

Petitioner's expert did not make inconsistent statements

176. Gallagher discloses that its computer processing system is configured to determine the location of each road marker tested. *Supra* Section VIII.A.11.g (Ground 1, [1H]). Gallagher discloses that 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, a POSITA would have understood that this GPS position of the vehicle corresponds to the location of the active sensor. Accordingly, a POSITA would have recognized that additional steps would have been necessary to also determine the location of the markers. Gallagher [0048].

Thorpe Decl. (Ex. 1003), ¶ 176.

Dr. Thorpe’s testimony remained consistent between his initial and supplemental declarations

43. For claim 9’s “analyze” function and claim 1’s location-determination function, I disagree with Patent Owner and Dr. Papanikolopoulos that Gallagher only discloses giving “the location of *the vehicle* at the time the road marker is detected,” not the location of the road marker itself. POR 29, 33; Ex. 2023, ¶ 107. Gallagher discloses that its GPS “can be used to pinpoint the position of the vehicle” *and* the position of the “markers 2 as measurements are being taken.” Gallagher, [0048], [0063]. The field of view for measuring reflectivity is fixed relative to the vehicle during use. Gallagher, [0035]–[0036]. Gallagher’s computer, in addition to knowing where the vehicle is, knows the geometry of the sensor and its field of view relative to the sensor. So even though the GPS data is directly tied to the position of the vehicle, it would have been a simple matter of translation to convert the GPS location information to the location of the road marker. Instead of recording just the vehicle position, Gallagher’s computer records the position of each marker.

Thorpe Suppl. Decl. (Ex. 1030), ¶ 43

Motivation to Combine Gallagher, Schofield, and Frank (Ground 2)

Prior art: Frank (Ex. 1007)

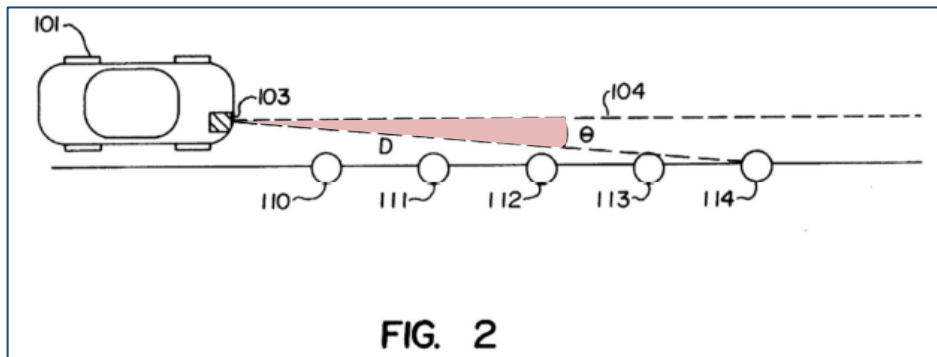


FIG. 2

Frank (Ex. 1007), Fig. 2

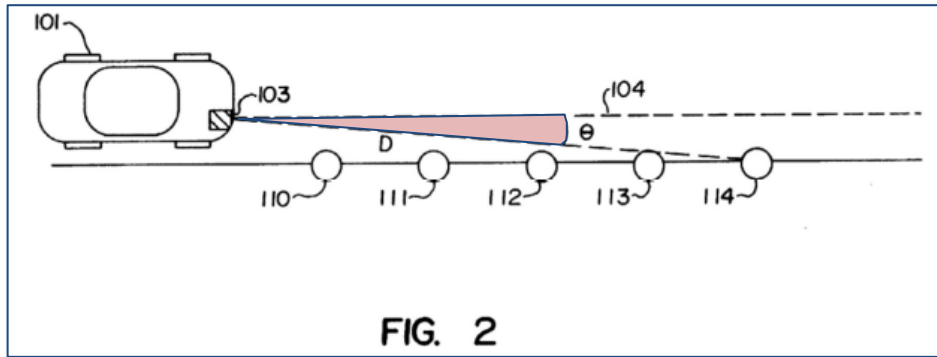
tors. Referring to FIG. 2, the reflected signal laser radar apparatus 103 calculates the distance D between vehicle 101 to the retroreflector and the angle θ formed between axis 104 and an imaginary line drawn between vehicle 101 and a retroreflector, for example retroreflector 114. Axis 104 is an imaginary line formed paral-

Frank (Ex. 1007), 4:37-42

911, 912 and 913. The time delay between the transmitted and received pulses is compared to calculate the distance D between vehicle 101 and each retroreflector 911, 912 and 913. Since floodlight beam 946 is not scanned by mirror surface 430 as shown in FIG. 4, the angle θ data must be produced by using a photodiode array for optical receiver 942. The position of the received light pulse on the photodiode array will determine the angle θ .

Frank (Ex. 1007), 10:64-11:4

Motivation to combine Gallagher, Schofield, and Frank



Pet. 44-47 (Frank (Ex. 1007), Fig. 2

**Frank's laser sweep improves
Gallagher's determination of
object location**

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, 69; Ex. 1014, 21. For example, the observation angle changes “rapidly” once the vehicle gets close to the retroreflective surface. Ex. 1015, 67. Accordingly, 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” (e.g., using “a laser rangefinder”) and take measurements within “a ‘distance window’” “to maintain sufficient accuracy.” Ex. 1014, 15, 21, 24. 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 through simple, well-known trigonometry.

Thorpe Decl. (Ex. 1003), ¶ 135

Motivation to Combine Gallagher, Schofield, Frank, and ASTM (Ground 3)

Prior art: ASTM (Ex. 1008) + Motivation to Combine

TABLE 1 Coefficient of Luminous Intensity R_l

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

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

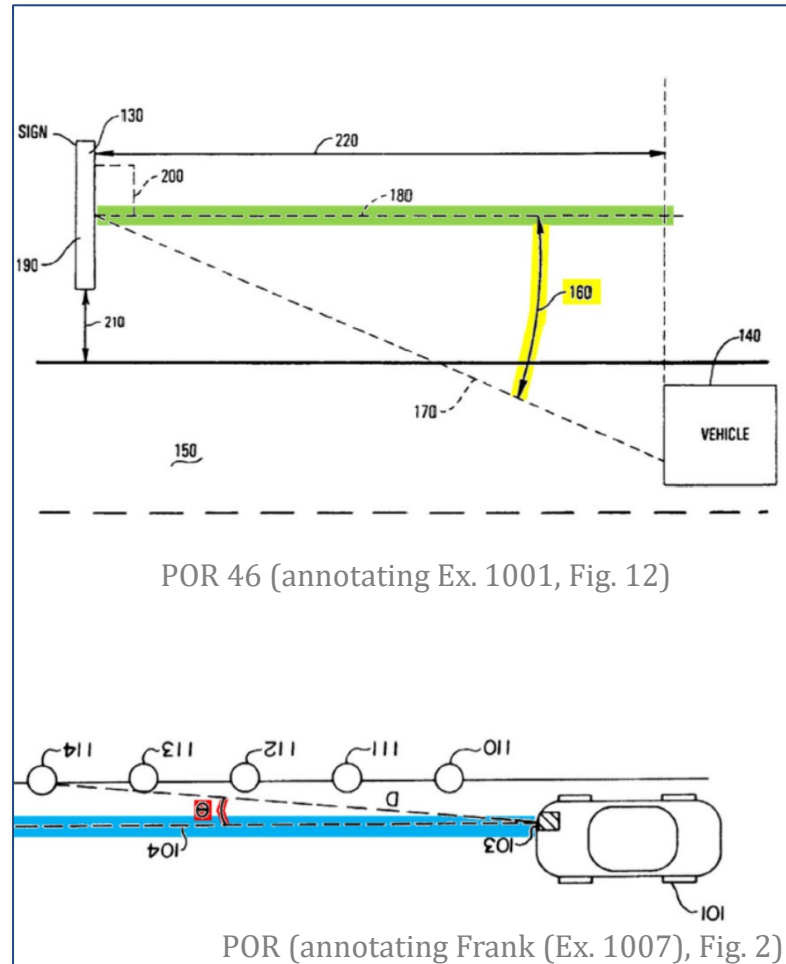
Entrance Angle β_2	Observation Angle α	Minimum Value R_l , cd/lc				
		White	Yellow	Red	Green	Blue
0° $+20^\circ/-20^\circ$	0.2°	3.0	1.8	0.75	1.0	0.28
	0.2°	1.2	0.72	0.3	0.4	0.11

ASTM (Ex. 1008), Table 1

153. A POSITA would have, therefore, 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 and angle of the light source relative to the vehicle's heading 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]. 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 Decl. (Ex. 1003), ¶ 153

Prior art: ASTM (Ex. 1008) + Motivation to Combine

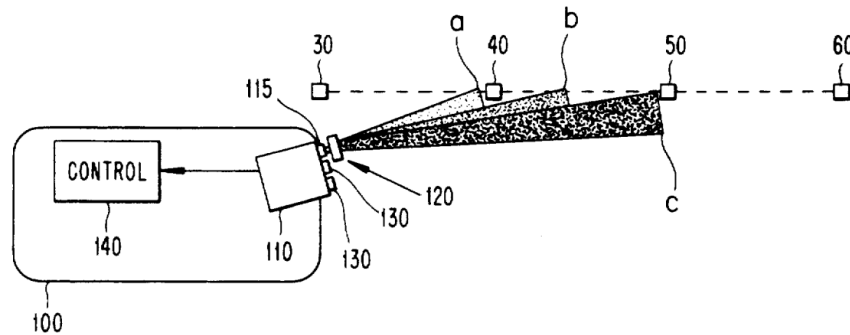


Ex. 1001, Fig. 12; Frank (Ex. 1007), Fig. 2; Pet. 57-60; POR 46; Pet'r Reply 25-27

Motivation to Combine Gallagher, Schofield, Leonard, and Popovich (Ground 4)

Prior art: Leonard (Ex. 1009)

Fig. 3



Leonard (Ex. 1009), Fig. 3

According to an exemplary vehicle guidance embodiment of the present invention, a system is used to detect markers placed at periodic distances along a vehicle path to provide information for vehicle control. An

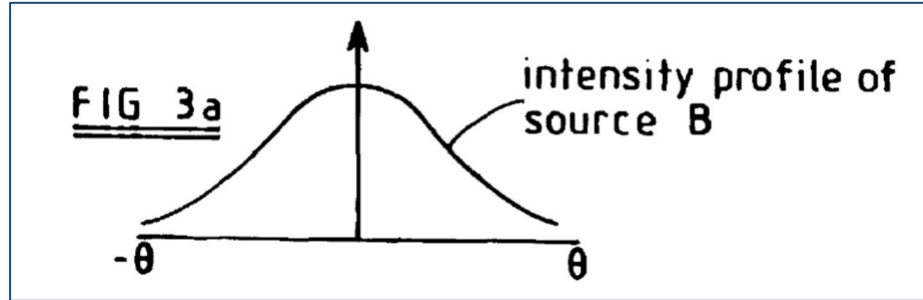
Leonard (Ex. 1009), 3:15-18

The power of each order required for a specific application can be selected on a trial and error basis. The sub-field illumination intensity for the most distant target is set to the intensity of the system without the grating 120. Although only three sub-fields are used to detect markers in accordance with the exemplary embodiment described herein, any number of sub-fields can be created and any or all of the sub-fields created can be used for object detection. Each sub-field can be used to detect the distance and angular orientation of any number of objects located within the sub-field in a manner similar to that described in the aforementioned commonly assigned U.S. patent application. FIG. 1c illustrates use of two overlapped sub-fields for detecting the three markers of FIG. 1a.

Leonard (Ex. 1009), 5:50-64

Leonard (Ex. 1009), 3:15-18, 5:50-64, Fig. 3; Pet. 61-62

Prior art: Popovich (Ex. 1010)



Popovich (Ex. 1010), Fig. 3a

spot intensity is characterised in terms of a number of grey levels - typically up to 256. By measuring the position in the matrix of the sensor(s) of the peak of the spot's intensity profile or, in the case of a spot having a flat topped profile, its centroid and using the known orientation in space of the sensor camera it is possible to define a ray vector that passes through the centre of the retroreflector 3.

Popovich (Ex. 1010), 6-7

Ex. 1010, 5-7, Fig. 3a; Pet. 62-63

Motivation to Combine Gallagher, Schofield, Leonard, 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.

Pet. 64

Pet. 64-73

IPR2024-01110
U.S. Patent No. 9,335,255

U.S. Patent No. 9,335,255

U.S. Patent No. 9,335,255 “System and Assessment of Reflective Objects Along a Roadway”

(12) **United States Patent**
Retterath et al.

(10) **Patent No.:** US 9,335,255 B2
(45) **Date of Patent:** *May 10, 2016

(54) **SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY**

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(72) Inventors: **James E. Retterath**, Excelsior, MN (US); **Robert A. Laumeyer**, Eden Prairie, MN (US)

(73) Assignee: **Facet Technology Corp.**, Eden Prairie, MN (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: 14/812,735

(22) Filed: **Oct. 13, 2014**

(65) **Prior Publication Data**
US 2015/0153271 A1 Jun. 4, 2015

Related U.S. Application Data

(60) Continuation of application No. 14/025,614, filed on Sep. 12, 2013, now Pat. No. 8,660,344, which is a division of application No. 13/205,337, filed on Aug. 8, 2011, now Pat. No. 8,660,311, which is a division of (Continued)

(51) **Int. Cl.**
G01N 21/55 (2014.01)
G01N 21/25 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC: **G01N 21/251** (2013.01); **G01N 21/55** (2013.01); **G01N 21/84** (2013.01); **G01S 17/06** (2013.01); **G06C 1/06758** (2013.01); **G06C**

(58) **Field of Classification Search**
CPC: G02B 5/124; G02B 1/04; G02B 1/105; G02B 1/18; G02B 2027/014; G02B 2027/0187; G02B 27/0101; G02B 5/0236; G02B 5/04; G02B 5/122; G02B 6/0018; G02B 6/0028; G02B 6/003; G02B 6/0065; G02B 6/00
See application file for complete search history.

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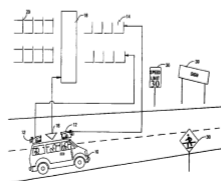
(56) **U.S. PATENT DOCUMENTS**
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(Continued)

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Dominant Color Transform and Circular Pattern Vector for Traffic Sign Detection and Recognition, Jung Hak and Tae Young Choi, IEEE Transaction Fundamentals, vol. 133-A, No. 6, pp. 1126-1135, Jun. 1998.
(Continued)

Primary Examiner—Michael P. Staffa
(74) **Attorney, Agent, or Firm**—Patterson Thuenke Pedersen, P.A.

(57) **ABSTRACT**
A system for the assessment of reflective surfaces disposed along a roadway repeatedly illuminates an area along the roadway that includes at least one reflective surface using a light source. Multiple light intensity values are measured over a field of view which includes at least a portion of the area illuminated by the light source. A computer processing system is used to identifying a portion of the light intensity values associated with a reflective surface and analyze the portion of the light intensity values to determine assessment for that reflective surface.

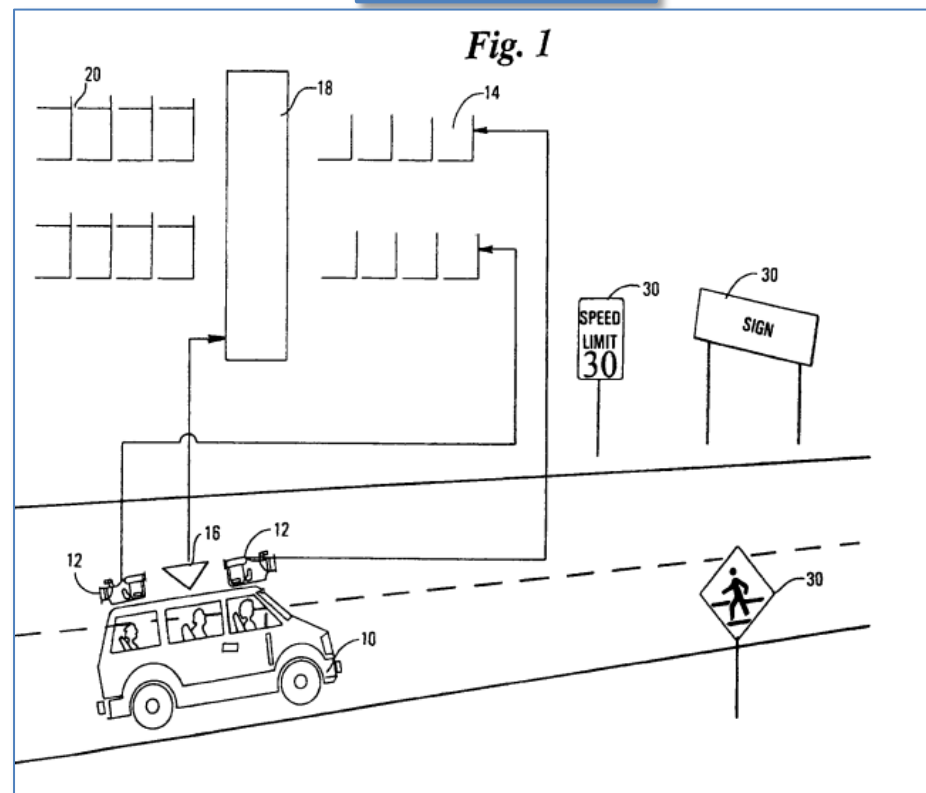
23 Claims, 19 Drawing Sheets



Page 1 of 32

MOBILEYE EXHIBIT 1001

The '255 Patent



'255 Patent (Ex. 1001), Fig. 1

Ex. 1001, Cover, Fig. 1; Pet. 2-6

Remaining Unpatentability Ground

Ground	Claims	Obviousness Basis
~~1~~	~~12, 14, 17, 21, 23~~	~~Gallagher~~
2	~~13~~ , 15	Gallagher and Lumia
~~3~~	~~18, 19~~	~~Gallagher and Schofield~~
~~4~~	~~20~~	~~Gallagher and Frank~~
~~5~~	~~22~~	~~Gallagher and Currie~~

Pet. 2

- Claim 15 is the sole remaining challenged claim after Patent Owner's disclaimer
- Claim 15 depends from independent claim 12

'255 Patent – Dependent Claim 15

12. An automated method of assessing reflective surfaces disposed along a roadway comprising:

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;

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

using a computer processing system configured to:

identify a portion of at least one light intensity value of the plurality of light intensity values associated with one of the at least one reflective surface of the road marker; and

analyze the portion of the at least one light intensity value of the plurality of light intensity values to determine an assessment for the reflective characteristic of the road marker.

Not disputed

- Disputes:

- The proper claim construction for “characterization profile”
- Whether the prior art teaches “determining a luminance value”
- Motivation to combine

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

'255 Patent (Ex. 1001), claims 12, 15

Ex. 1001, claims 12, 15

Prior art: Gallagher (Ex. 1005)

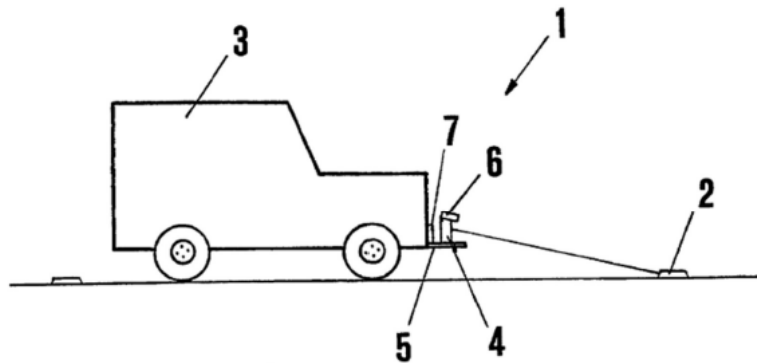
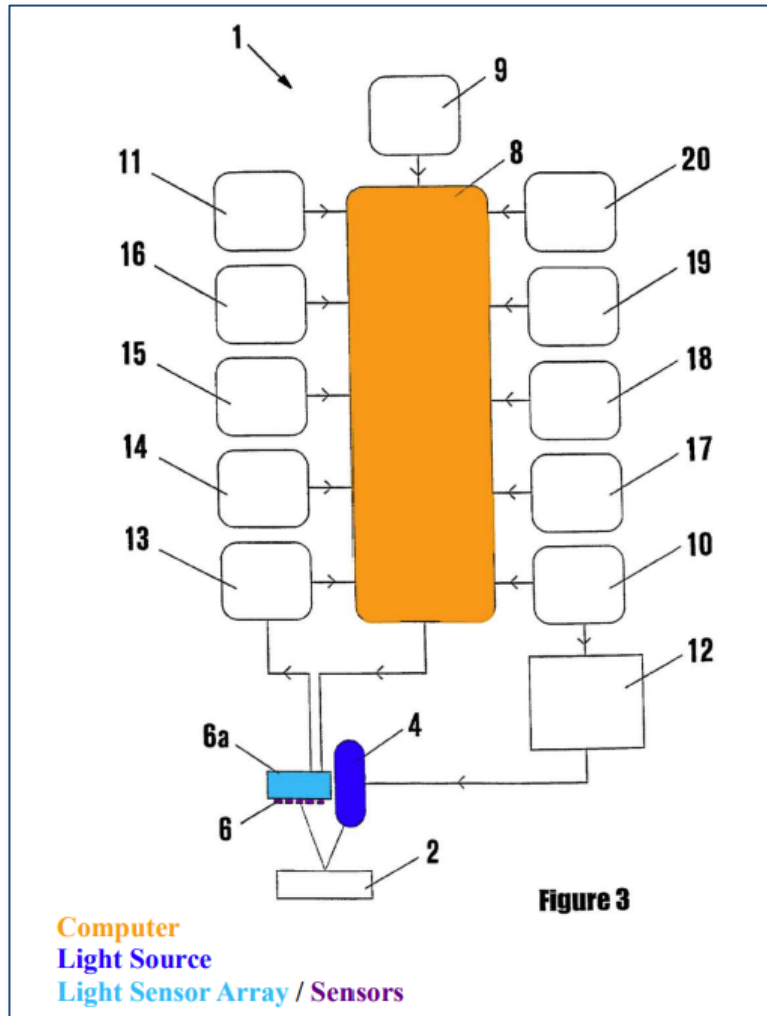


Figure 1

[0032] The apparatus 1 is designed to measure the reflectivity of road markings 2 when in transit. The apparatus 1 is mounted on a moveable platform in the form of a vehicle 3. The apparatus 1 can obtain reflectivity measurements, inter alia, with the vehicle 3 travelling at speeds of up to about 100 kph. This means that testing can be carried out alongside other vehicles on a road without being an inconvenience or impediment to the normal flow of traffic.

[0033] The apparatus 1 can test the reflectivity of a wide variety of reflective road markings and road markers such as, for example, road signs and posts, reflective painted lines whether continuous or broken, and more particularly raised pavement markers. For simplicity the description of the preferred embodiment of the invention will be limited to raised pavement markers 2 (referred to herein as “markers”). However, it will be appreciated by those skilled in the art that the apparatus 1 can be adapted to measure other types of reflective markings on or adjacent the road.

Prior art: Gallagher (Ex. 1005)



Pet. 11-13 (annotating Gallagher (Ex. 1005), Fig. 3)

[0038] A light sensor 6 detects the reflected light from a marker 2. In this embodiment sensor arrays containing a plurality of sensors, generally five or ten, are advantageously aligned in an encased module 6a to increase the field of view of the apparatus 1. The module 6a is adjustable to increase the accuracy of the measurements.

[0045] The processing means is in the form of a computer 8 programmed by a computer program 9 to carry out a method of testing the integrity of road markings according to an aspect of the invention.

[0046] In operation, an operator in the vehicle 3 initiates the measurement process by sending a signal via the computer 8 to activate the light control relay 10. This is conveniently achieved by using a control box 11 located by the operator in the vehicle 3. The relay 10 switches power from the power supply 12 to the light source 4. The light source 4 subsequently illuminates a reflective surface of a marker 2 and the reflected light is detected by one or a number of the light sensors 6 in the module 6a which has been aligned to detect light from a particular area of road.

Prior art: Lumia (Ex. 1014)

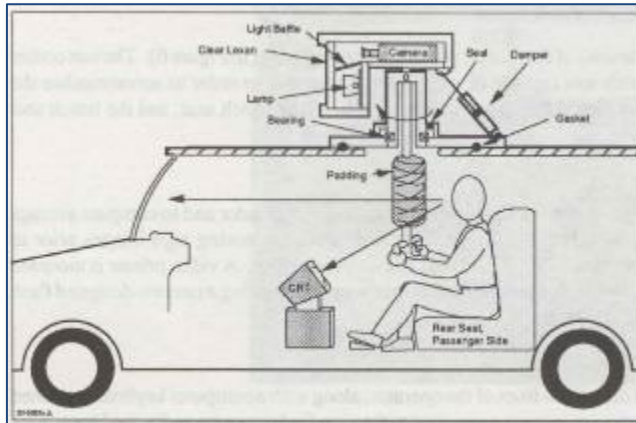


Figure 4. Conceptual design of MSMRTS mobile prototype.

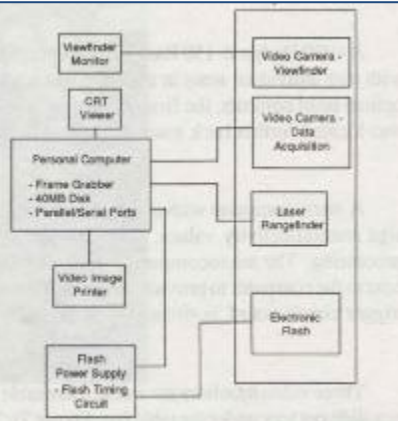


Figure 5. Block diagram of MSMRTS mobile prototype.

Lumia (Ex. 1014), Figs. 4-5)

The goal of this system is to measure the Coefficient of Retroreflection, or R' , in units of candelas per footcandle per square foot. This can be expressed as:¹

$$R' = \frac{I}{E_n A} \quad (1)$$

where E_n is the normal illumination incident on the retroreflector, A is the area of the surface to be measured, and I is the reflected intensity. By suitable manipulation of these parameters, the retroreflectance can essentially be regarded as the absolute brightness of the retroreflective target for a given amount of incident illumination on the target. Arithmetically, this can be expressed as:

$$R' = \frac{L}{E_n} \quad (2)$$

where L is the luminance of the reflected light. Figure 2 shows the commonly accepted

Lumia (Ex. 1014), 16

The video system takes advantage of the contrast which typically exists between legend and background, anticipating a “bimodal” reflected intensity distribution. That is, the contrast difference allows the use of simple software algorithms to identify and group areas of similar intensity. For a typical two-color sign, these groups are expected to represent sign legend and background. The average value of each group corresponds to the average luminance, when properly calibrated. Assuming the illumination is known, the retroreflectance is readily obtained using Equation 2.

Lumia (Ex. 1014), 16

Issue 1: Claim Construction for “Characterization Profile”

“Characterization Profile” should be interpreted consistent with the specification, not Facet’s atextual position

Term	The Board’s Preliminary Construction	Facet’s Position
“characterization profile”	“a conversion factor to convert measured light intensity into luminance” 	“a compilation, presented in a usable format, of the description of the properties and performance characteristics of a sensors across various conditions”

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

“Characterization Profile”: Specification

value. Intensity values will vary according to the color of the reflected light, since not all colors of incoming light excite the light intensity sensor 280 pixels in the same way. By knowing the background or foreground color of the object of interest 460 along with the light intensity sensor's 280 ability to sense, or the light intensity sensor's 280 profile for a particular color, the intensity value 300 for a particular color can be converted into a luminance value. Light intensity sensor 280 characterization is essential for high precision computations since N photons of a given particular color (or wavelength) of light will represent a different gray value (intensity level) in the sensor than N photons of another color (or wavelength) of light. The look-up-table (LUT) 475 shown in FIG. 7 is a digital table stored in memory that uses the indexes of intensity (a single gray level value from the intensity measurement 300) and sheeting color to determine the luminance. The light

'255 Patent (Ex-1001), 11:41-56

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

Ex. 1001, 20:12-15

Facet’s construction conflicts with law

Term	The Board’s Preliminary Construction	Facet’s Position
“characterization profile”	Intrinsic Record 	Extrinsic Evidence

Issue 2: Determining a Luminance Value

Lumia's Full Disclosure

3. BACKGROUND

$$R' = \frac{L}{E_n} \quad (2)$$

where L is the luminance of the reflected light. Figure 2 shows the commonly accepted

Lumia (Ex. 1014), 16

view (FOV) of the detector is limited to a sufficiently small angle. The use of a video camera effectively divides the FOV defined by the system magnification into smaller FOV's, thereby creating individual luminance meters at each sensing element site. In effect, the use of a video camera is a practical way for obtaining a large number of measurement samples from the sign so that representative legend and background retroreflectances may be calculated.

The video system takes advantage of the contrast which typically exists between legend and background, anticipating a "bimodal" reflected intensity distribution. That is, the contrast difference allows the use of simple software algorithms to identify and group areas of similar intensity. For a typical two-color sign, these groups are expected to represent sign legend and background. The average value of each group corresponds to the average luminance, when properly calibrated. Assuming the illumination is known, the retroreflectance is readily obtained using Equation 2.

Lumia (Ex. 1014), 16

Patent Owner Improperly Limits Lumia to Only What Is Described in the Experimental Results Section

3. BACKGROUND

$$R' = \frac{L}{E_s}$$

(2)

Lumia (Ex. 1014), 16

Patent Owner takes issue with *where* in Lumia it discloses relevant material (e.g., separate sections)

6. EXPERIMENTAL RESULTS

Ten signs were measured with the mobile system and compared to data obtained with a calibrated hand-held retroreflector. The signs used for this experiment had a white background color with background R' values ranging from approximately 4 to 350. Calibration of the system was accomplished by acquiring an image of a calibrated white sheeting material and **computing a scale factor to convert the 8-bit digital gray levels of the calibration target image to R' values.** Sixteen image samples were obtained for each sign using an observation angle of 0.2° and at a distance of 200 feet ("highway" mode). The same signs were measured by an Advanced Retro Technology 910F hand-held retroreflector (HHRR) calibrated with the same calibration target used to calibrate the MSMRTS. Six randomly distributed HHRR measurements of the sign background were made for each sign.

Lumia (Ex. 1014), 24

Lumia (Ex. 1014), 15-16, 24; Pet. 14-19, 44-47; Pet'r Reply 11-15

Patent Owner Attacks the Disclosure for Appearing in Different Sections

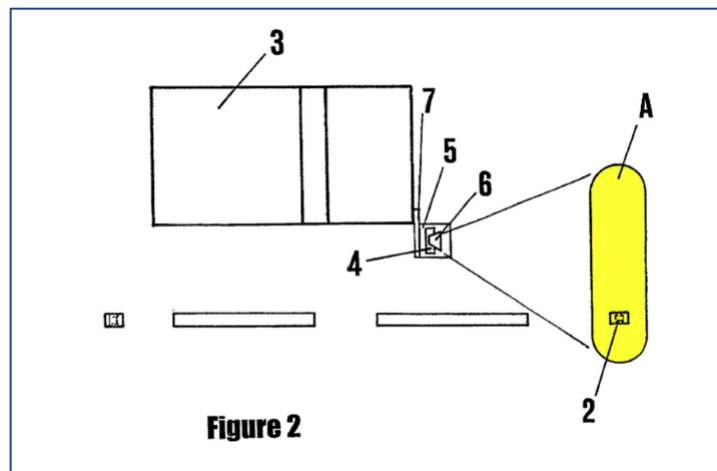


“A reference must be considered for everything that it teaches, not simply the described invention or a preferred embodiment.”

In re Applied Materials, Inc., 692 F.3d 1289, 1298 (Fed. Cir. 2012)

Issue 3: Motivation to Combine Gallagher and Lumia

The Combination Detects Luminance Values of Road Markers

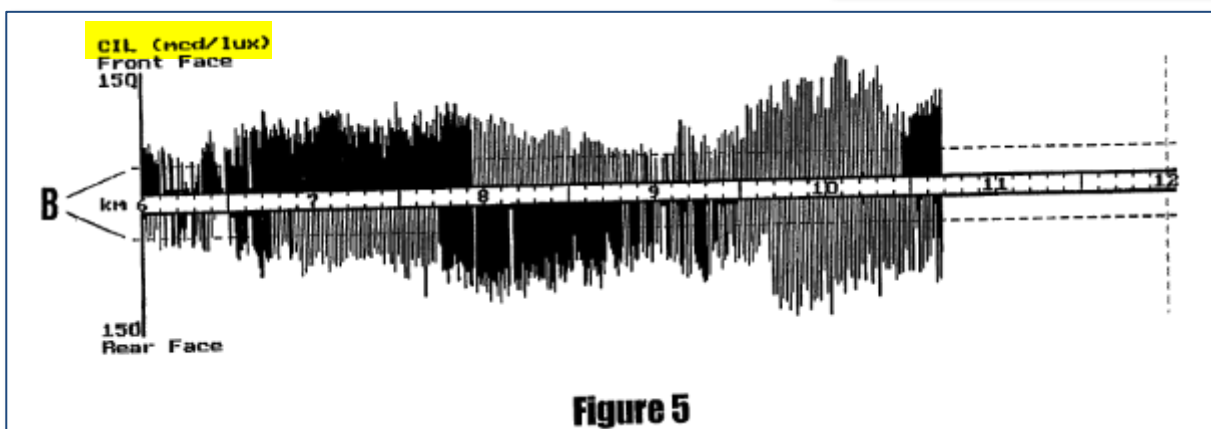


Gallagher (Ex. 1005), Fig. 2

[0066] Process step g. involves selecting, from data obtained in step a., which reflectance levels indicate a road marker. In the case of road markers the peak responses sensed are determined as the highly reflective surfaces of a road marker.

[0067] Process step h. involves determining the reflectance level of the road marker in a value of millicandela per Lux (CIL) or as a percentage of the predetermined standard reflectance level.

Gallagher (Ex. 1005), [0066]-[0067]



Gallagher (Ex. 1005), Fig. 5

The Combination Determines Luminance Values of Road Markers

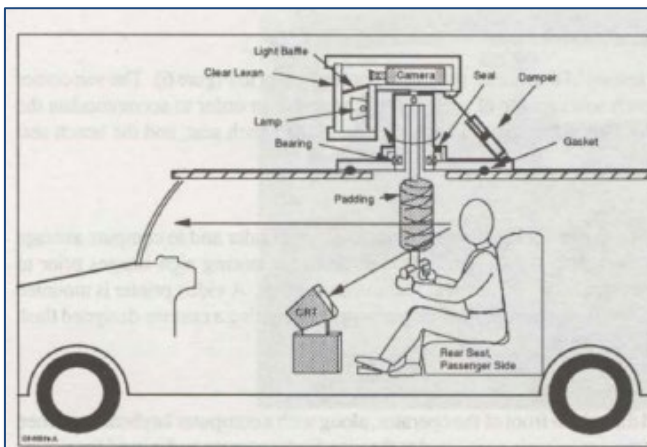


Figure 4. Conceptual design of MSMRTS mobile prototype.

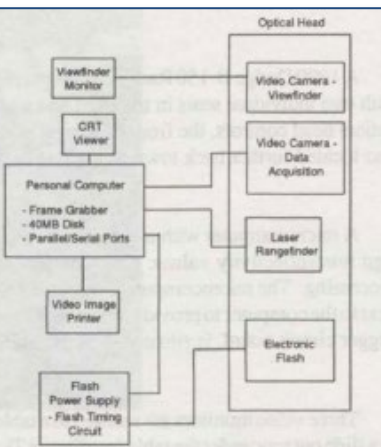


Figure 5. Block diagram of MSMRTS mobile prototype.

Lumia (Ex. 1014), Figs. 4-5

The goal of this system is to measure the Coefficient of Retroreflection, or R' , in units of candelas per footcandle per square foot. This can be expressed as:¹

$$R' = \frac{I}{E_n A} \quad (1)$$

where E_n is the normal illumination incident on the retroreflector, A is the area of the surface to be measured, and I is the reflected intensity. By suitable manipulation of these parameters, the retroreflectance can essentially be regarded as the absolute brightness of the retroreflective target for a given amount of incident illumination on the target. Arithmetically, this can be expressed as:

$$R' = \frac{L}{E_n} \quad (2)$$

Lumia (Ex. 1014), 16

[0039] The sensors are photodiodes mounted precisely on the module 6a at a height and angle to properly detect reflected light. A variety of light sensors are envisaged as being suitable in the apparatus 1. In the case of sensing coloured markers, light sensors with different spectral responses or similar light sensors with different filters can be used. The data signals detected by the sensors will indicate the colour of a road marking being tested. This feature is useful in situations where the apparatus 1 is being used to test different coloured road markings simultaneously.

Gallagher (Ex. 1005), [0039]

view (FOV) of the detector is limited to a sufficiently small angle. The use of a video camera effectively divides the FOV defined by the system magnification into smaller FOV's, thereby creating individual luminance meters at each sensing element site. In effect, the use of a video camera is a practical way for obtaining a large number of measurement samples from the sign so that representative legend and background retroreflectances may be calculated.

The video system takes advantage of the contrast which typically exists between legend and background, anticipating a "bimodal" reflected intensity distribution. That is, the contrast difference allows the use of simple software algorithms to identify and group areas of similar intensity. For a typical two-color sign, these groups are expected to represent sign legend and background. The average value of each group corresponds to the average luminance, when properly calibrated. Assuming the illumination is known, the retroreflectance is readily obtained using Equation 2.

Lumia (Ex. 1014), 16

Appendix

328 Patent – Ground 1 Claims (1-4, 8-13)

1. 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:

- an image capture system that captures images within a field of view along the roadway;

- an active light sensor including:

 - a light source that illuminates an area along the roadway; and

 - a light sensor that measures light intensity values within at least a portion of the area illuminated by the light source; and

- 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:

 - determine whether the object of interest includes a reflective surface based on the light intensity values;

 - determine whether the reflective surface is a road marker based on an assessment of the reflective surface; and

 - determine a location of the road marker.

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.

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.

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.

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.

9. An automated system for assessing reflective surfaces disposed along a roadway comprising:

- 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:

 - a light source to illuminate an area that includes the at least one reflective surface; and

 - 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

- 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:

 - 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

 - 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.

328 Patent – Ground 1 Claims (1-4, 8-13)

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

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.

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.

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.

328 Patent – Ground 2 Claims (15-16)

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.

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.

328 Patent – Ground 3 Claim (14)

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.

328 Patent – Ground 4 Claims (5-7)

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.

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.

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.

255 Patent - Claims

12. An automated method of assessing reflective surfaces disposed along a roadway comprising:
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;
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
using a computer processing system configured to:
identify a portion of at least one light intensity value of the plurality of light intensity values associated with one of the at least one reflective surface of the road marker; and
analyze the portion of the at least one light intensity value of the plurality of light intensity values to determine an assessment for the reflective characteristic of the road marker.

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