CLAIMS

1. A method for determining sheeting type of a reflective sheeting material covering at least a portion of a surface of a road sign comprising:

using a light source to illuminate at least a portion of the reflective sheeting material covering the road sign as the light source is traversed along the roadway;

collecting a plurality of light intensity measurements reflected from the at least a portion of the reflective sheeting material to generate an as-measured retroreflectivity profile, the light intensity measurements corresponding to exemplary angular displacements of incident light from a reference position; and

determining sheeting type of the reflective sheeting material based on the as-measured retroreflectivity profile.

2. The method of claim 1, wherein determining sheeting type of the reflective sheeting material further comprises:

providing a database of retroreflectivity profiles, each retroreflectivity profile having an associated known sheeting type;

selecting a retroreflectivity profile from the retroreflectivity profile pool that best correlates to the as-measured retroreflectivity profile; and

determining sheeting type of the retroreflective sheeting material based on the retroreflectivity profile associated with the selected retroreflectivity profile.

3. The method of claim 2, wherein the known sheeting type is selected from the group consisting of Type I (Engineer Grade), Type III (High Intensity), and Type VII (Prismatic).

4. The method of claim 3, wherein the Prismatic is one of Type VIIa (Diamond Grade VIP) and Type VIIb (Diamond Grade LDP).

5. The method of claim 2, wherein the providing step comprises establishing a functional relationship between a plurality of exemplary instances of retroreflectivity values corresponding to each known sheeting type and a plurality of instances of one of an observation angle and an entrance angle.

6. The method of claim 2, wherein the retroreflectivity profile is a characteristic curve of retroreflectivity values represented as a function of one of a monotonically varying observation angle and an entrance angle.

7. The method of claim 2, wherein the as-measured retroreflectivity profile is a curve of retroreflectivity values calculated from the plurality of light intensity measurements plotted as a function of the exemplary angular displacements of incident light from a reference position.

8. The method of claim 7, 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 sign.

9. The method of claim 7, wherein each of the exemplary angular displacements comprises an entrance angle corresponding to one of a plurality of distances of the road sign from the road sign.

10. The method of claim 7, wherein each of the exemplary angular displacements comprises an observation angle corresponding to one of a plurality of distances of the light source from the road sign.

11. The method of claim 2, wherein the selecting step comprises:

providing a computer model coding a function for obtaining a set of coordinates from each retroreflectivity profile, each coordinate comprising a pairing of a retroreflectivity value and an associated angular displacement, wherein the function associates the retroreflectivity value to the angular displacement;

applying the computer model to the retroreflectivity profiles in the retroreflectivity pool to generate a set of reference coordinates for each retroreflectivity profile, each set of reference coordinates defining a characteristic curve having a characteristic shape;

applying the computer model to the as-measured retroreflectivity profile to obtain a set of as-measured coordinates defining an as-measured performance curve having an as-measured shape; and

selecting the characteristic curve having the characteristic shape which best approximates the as-measured shape.

12. The method of claim 11, wherein the selecting step comprises:

computing parameters to provide a best-fit curve to the set of as-measured coordinates;

scaling the characteristic curves to obtain a scaled characteristic curve with a characteristic shape such that the scaled characteristic curve is sized substantially the same as the as-measured performance curve; and

selecting the characteristic curve as acceptable if a deviation of the characteristic shape from the as-measured shape is within a predefined threshold.

13. The method of claim 12, wherein scaling the characteristic curves comprises multiplying the set of reference coordinates for each retroreflectivity profile by a positive scaling factor less than unity to obtain a set of scaled reference coordinates defining a scaled characteristic curve having a characteristic shape.

14. The method of claim 2, wherein the determining step comprises the steps of:

calculating a degree of correlation between the as-measured retroreflectivity profile and the selected retroreflectivity profile;

selecting the sheeting type associated with the selected retroreflectivity profile if the degree of correlation lies between an acceptable range of predefined values; and

identifying the road sign as exhibiting a gross failure of the reflective sheeting material covering at least a portion of the surface of the road sign if the degree of correlation lies outside the acceptable range of predefined values.

15. A method for determining sheeting type of a reflective sheeting material covering a road sign comprising:

means for illuminating at least a portion of the reflective sheeting material covering the road sign from a plurality of distances along the roadway;

means for collecting a plurality of light intensity measurements reflected from the at least a portion of the reflective sheeting material;

means for generating an as-measured retroreflectivity profile using the light intensity measurements corresponding to exemplary angular displacements of incident light from a reference position;

means for providing a database of retroreflectivity profiles with each retroreflectivity profile having an associated known sheeting type;

means for comparing the as-measured profile to each retroreflectivity profile from the retroreflectivity profile pool;

means for selecting the retroreflectivity profile that best correlates to the as-measured retroreflectivity profile; and

means for determining sheeting type of the reflective sheeting material based on the known sheeting type associated with the selected retroreflectivity profile.

16. The method of claim 15, wherein the means for determining sheeting type further comprises:

means for calculating a degree of correlation between the as-measured retroreflectivity profile and the selected retroreflectivity profile;

means for determining if the degree of correlation lies between an acceptable range of predefined values;

means for selecting the sheeting type associated with the selected retroreflectivity profile if the degree of correlation lies between an acceptable range of predefined values; and

means for classifying the road sign as exhibiting a gross failure of the reflective sheeting material covering at least a portion of the surface of the road sign if the degree of correlation lies outside the acceptable range of predefined values.

17. The method of claim 15, wherein the means for determining sheeting type further comprises:

means for computing parameters to provide a best-fit curve to the as-measured retroreflectivity profile, the best-fit curve having an as-measured shape;

means for scaling each retroreflectivity profile in the retroreflectivity pool to obtain a scaled characteristic curve sized substantially the same as the best-fit curve and having a characteristic shape; and

means for computing a deviation of the characteristic shape from the as-measured shape;

means for determining the sheeting type by identifying the sheeting type associated with the characteristic curve if the deviation of the characteristic shape from the as-measured shape is within a predefined threshold; and

means for filtering the road sign as exhibiting a gross failure of the reflective sheeting material covering at least a portion of the surface of the road sign if the deviation lies outside the predefined threshold.

18. A system determining sheeting type of a reflective sheeting material covering a road sign comprising:

at least one light source mounted on a vehicle capable of traversing a roadway and suitable for illuminating at least a portion of the road sign;

at least one light intensity sensor for receiving light reflected from the road sign and computing the intensity of the received light;

a positioning system for determining a location of the vehicle from a stationary frame of reference;

a ranging system for determining a distance of the road sign from the light source and an inclination of a surface of the road sign relative to the light source;

a control system operably connected to the light source, intensity sensor, positioning system and ranging system such that the intensity sensor, ranging system and positioning system record information associated with an area that includes at least one road sign as the vehicle traverses along the roadway in response to repeated illumination of the area by the light source; and

a computer processing system that utilizes the recorded information to determine an as-measured retroreflectivity profile having an as-measured shape and comprising the plurality of as-measured retroreflectivity values for the sheeting type of the road sign and

comparing the as-measured shape with a characteristic shape of at least one known retroreflectivity profile in a database of known retroreflectivity profiles for each of a plurality of different sheeting types to classify a sheeting material of the road sign as one of the plurality of different sheeting types.

19. A method for classifying a road sign having sheeting types having at least one color, each sheeting type of a particular color covering at least one non-overlapping area of the road sign, the method comprising the steps of:

using a light source to illuminate at least a portion of the reflective sheeting material covering the road sign as the light source is traversed along the roadway;

collecting a plurality of light intensity measurements reflected from the at least a portion of the reflective sheeting material to generate an as-measured retroreflectivity profile, the light intensity measurements corresponding to exemplary angular displacements of incident light from a reference position;

providing a database of retroreflectivity profiles, each retroreflectivity profile having an associated known sheeting type having a known color;

providing a database of road signs, each road sign categorized according to a set of colors associated with each known sheeting type covering the road sign;

selecting at least one retroreflectivity profile from the retroreflectivity profile pool that best correlates to at least a portion of the as-measured retroreflectivity profile;

determining a set of sheeting types associated with the selected retroreflectivity profiles; and

classifying the road sign according to the set of colors associated with the set of selected sheeting types.

Electronic Acknowledgement Receipt

EFS ID:	25710100
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	Jamie E. Retterath
Customer Number:	24113
Filer:	Bradley Pedersen/Michelle Arcand
Filer Authorized By:	Bradley Pedersen
Attorney Docket Number:	2806.03US09
Receipt Date:	06-MAY-2016
Filing Date:	
Time Stamp:	16:59:40
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	2803_03US09_ADS.pdf	1836517 ceacd1979b00f89718730023b016971fd28c2fae	no	9

Warnings:

Information:

2		2806_03US09_CONTAPPLN.pdf	156261 a6974d5fcb016cd367252c20477cef45f41c18c8	yes	42
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Specification		1	32	
	Claims		33	41	
	Abstract		42	42	
Warnings:					
Information:					
3	Drawings-only black and white line drawings	2806_03US09_DRAWINGS.pdf	250253 74cb5a6a648007b0e4acb0dff601696cead71ad8	no	18
Warnings:					
Information:					
		Total Files Size (in bytes):	2243031		

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<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

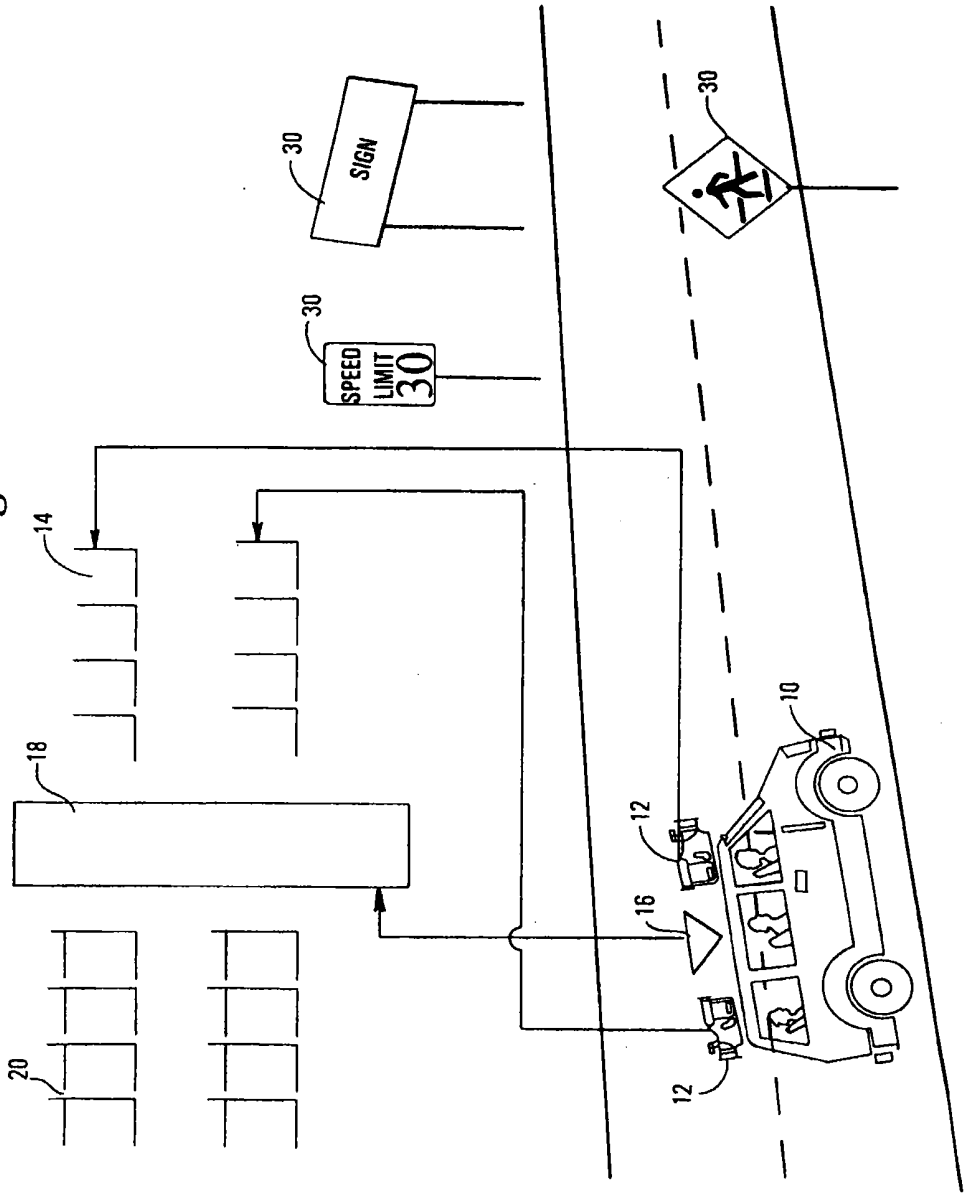


Fig. 1

Fig. 2

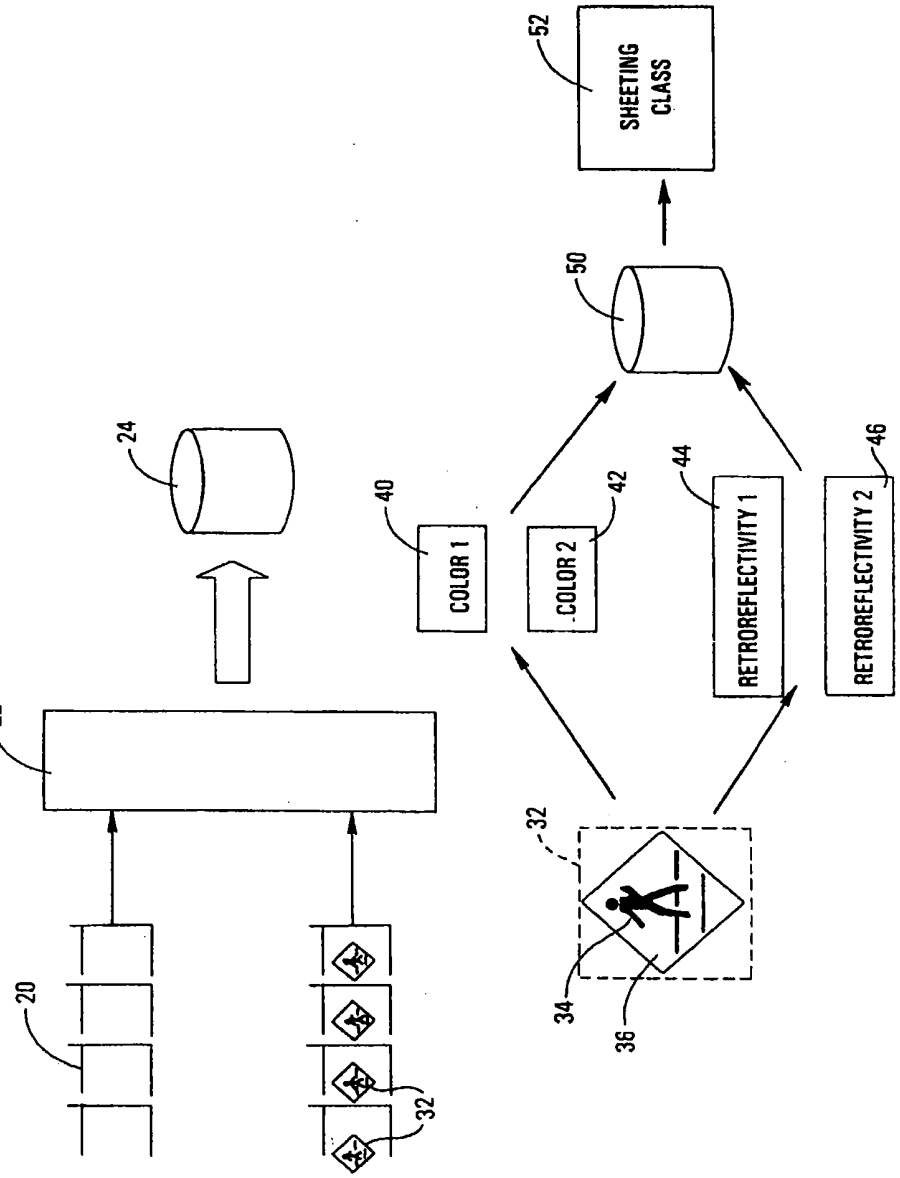
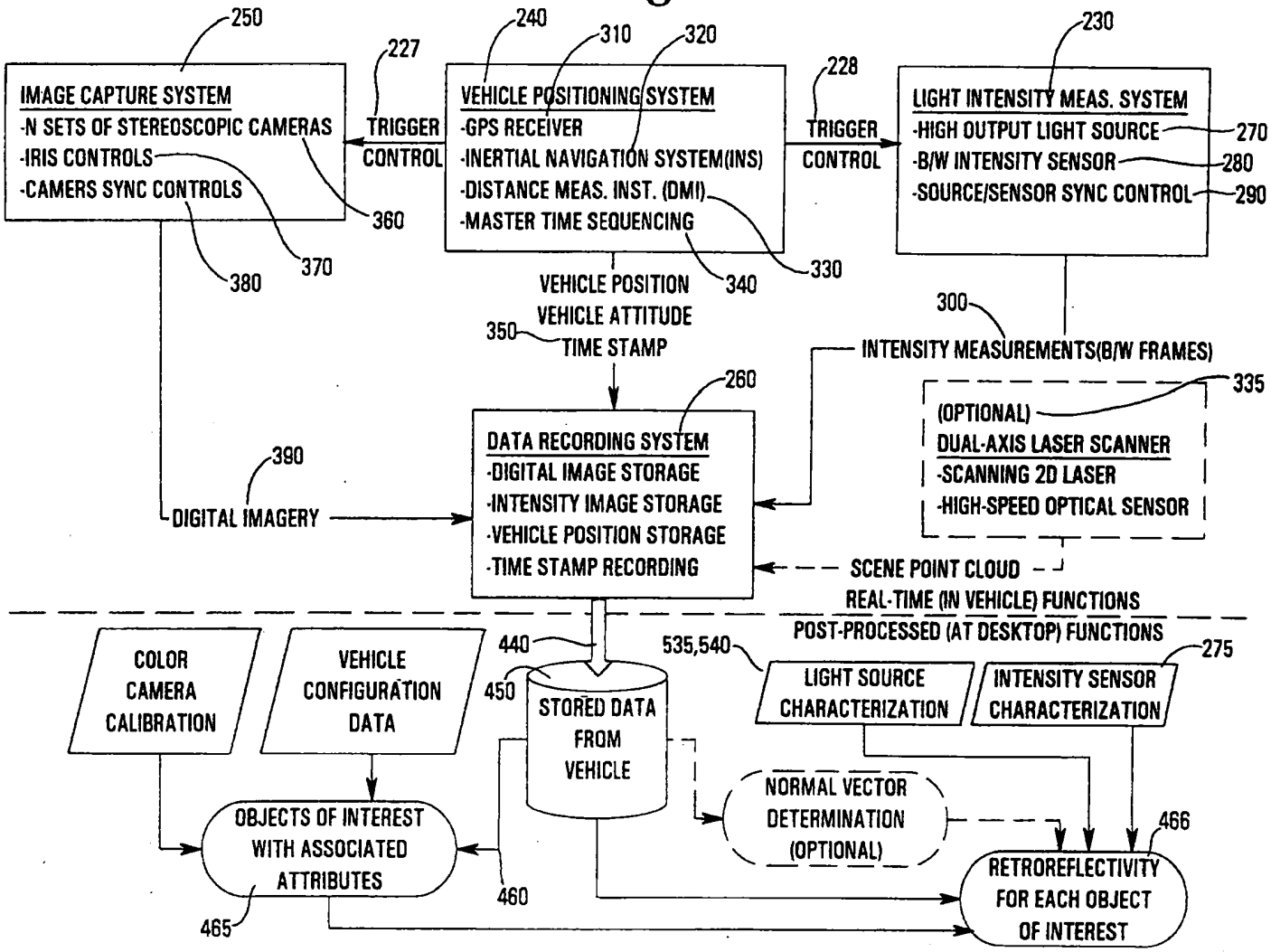

20
22
24
32
32
34
36
40
COLOR 1
42
COLOR 2
44
RETROREFLECTIVITY 1
46
RETROREFLECTIVITY 2
50
52
SHEETING CLASS

Fig.3


250
IMAGE CAPTURE SYSTEM
-N SETS OF STEREOSCOPIC CAMERAS
-IRIS CONTROLS
-CAMERS SYNC CONTROLS
227
TRIGGER
CONTROL
360
370
380
240
310
320
VEHICLE POSITIONING SYSTEM
-GPS RECEIVER
-INERTIAL NAVIGATION SYSTEM(INS)
-DISTANCE MEAS. INST. (DMI)
-MASTER TIME SEQUENCING
330
340
228
TRIGGER
CONTROL
230
LIGHT INTENSITY MEAS. SYSTEM
-HIGH OUTPUT LIGHT SOURCE
-B/W INTENSITY SENSOR
-SOURCE/SENSOR SYNC CONTROL
270
280
290
VEHICLE POSITION
VEHICLE ATTITUDE
350
TIME STAMP
300
INTENSITY MEASUREMENTS(B/W FRAMES)
335
(OPTIONAL)
DUAL-AXIS LASER SCANNER
-SCANNING 2D LASER
-HIGH-SPEED OPTICAL SENSOR
260
DATA RECORDING SYSTEM
-DIGITAL IMAGE STORAGE
-INTENSITY IMAGE STORAGE
-VEHICLE POSITION STORAGE
-TIME STAMP RECORDING
390
DIGITAL IMAGERY
SCENE POINT CLOUD
REAL-TIME (IN VEHICLE) FUNCTIONS
POST-PROCESSED (AT DESKTOP) FUNCTIONS
COLOR
CAMERA
CALIBRATION
VEHICLE
CONFIGURATION
DATA
440
450
STORED DATA
FROM
VEHICLE
535,540
LIGHT SOURCE
CHARACTERIZATION
INTENSITY SENSOR
CHARACTERIZATION
275
NORMAL VECTOR
DETERMINATION
(OPTIONAL)
OBJECTS OF INTEREST
WITH ASSOCIATED
ATTRIBUTES
460
465
466
RETROREFLECTIVITY
FOR EACH OBJECT
OF INTEREST

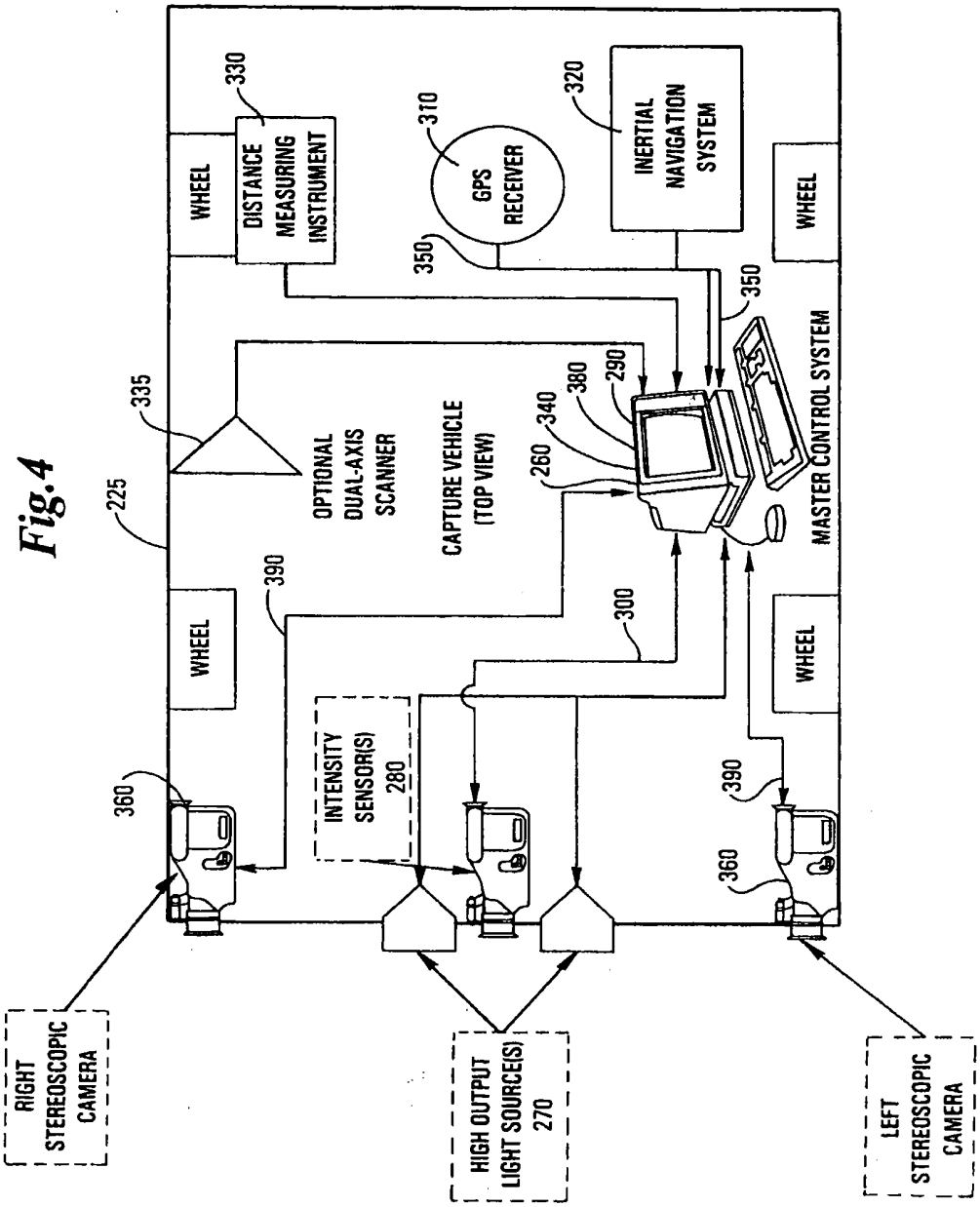

WHEEL
DISTANCE MEASURING INSTRUMENT
330
310
GPS RECEIVER
320
INERTIAL NAVIGATION SYSTEM
WHEEL
350
350
335
225
OPTIONAL DUAL-AXIS SCANNER
CAPTURE VEHICLE (TOP VIEW)
260
340
380
290
MASTER CONTROL SYSTEM
390
300
WHEEL
WHEEL
INTENSITY SENSOR(S) 280
360
390
360
RIGHT STEREOSCOPIC CAMERA
HIGH OUTPUT LIGHT SOURCE(S) 270
LEFT STEREOSCOPIC CAMERA

Fig.4

Fig.5

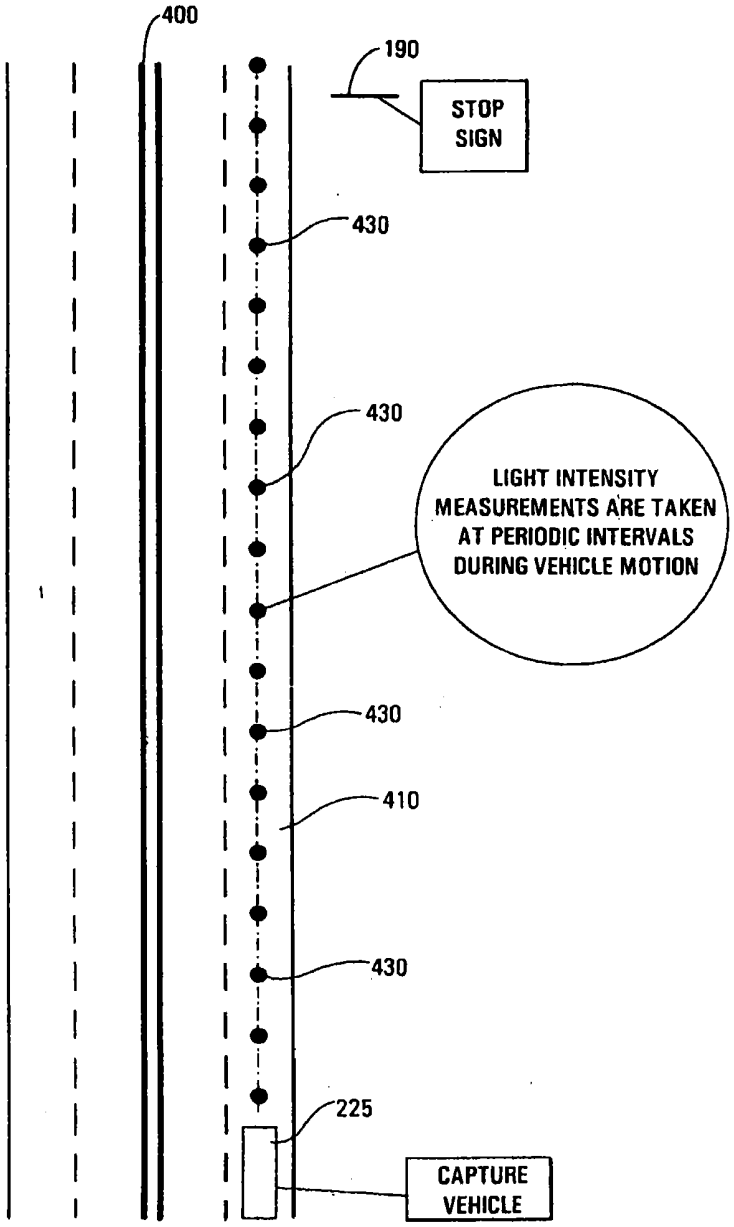

400
190
STOP SIGN
430
430
LIGHT INTENSITY MEASUREMENTS ARE TAKEN AT PERIODIC INTERVALS DURING VEHICLE MOTION
430
410
430
225
CAPTURE VEHICLE

Fig.6

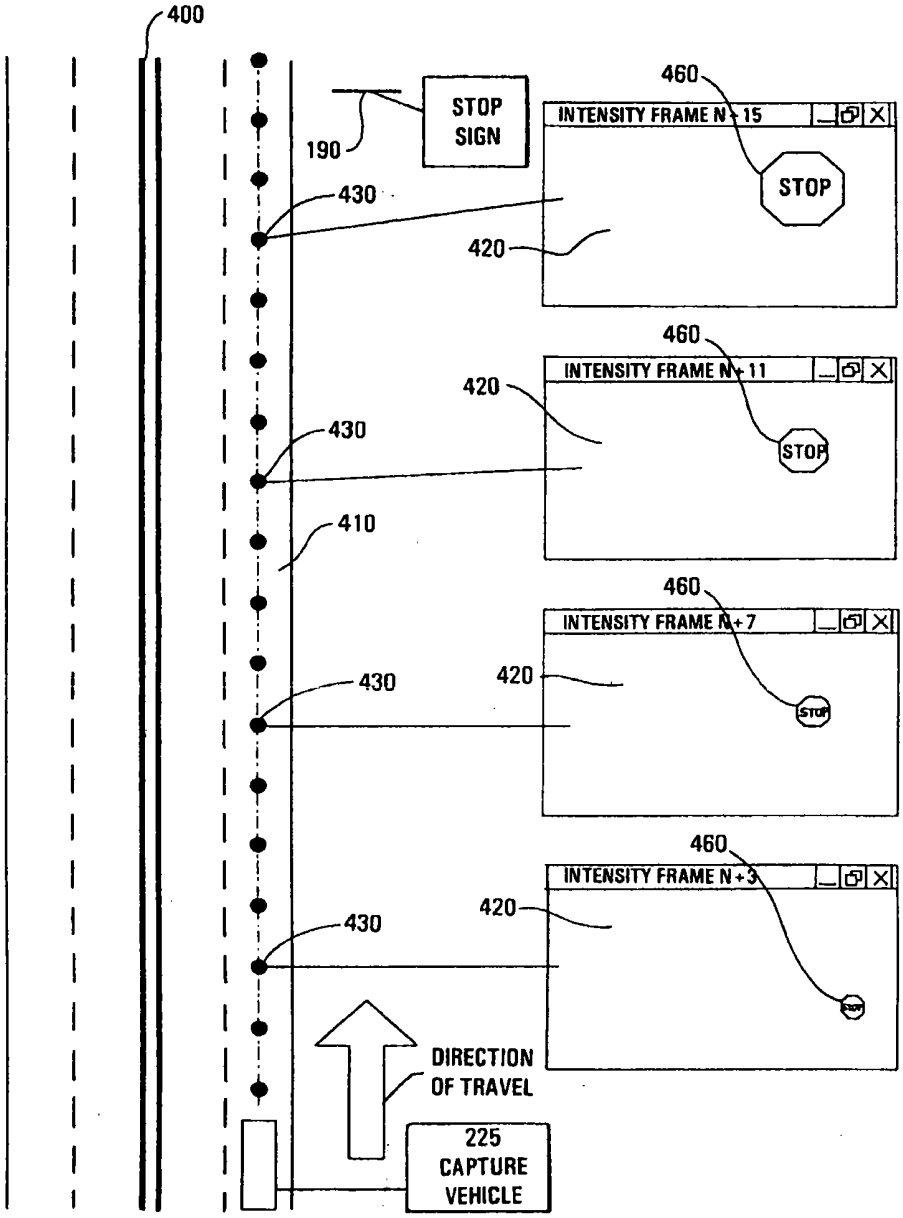

400
STOP SIGN
190
460
INTENSITY FRAME N+15
STOP
430
420
460
INTENSITY FRAME N+11
420
STOP
430
410
460
INTENSITY FRAME N+7
430
420
STOP
460
INTENSITY FRAME N+3
420
430
DIRECTION OF TRAVEL
225 CAPTURE VEHICLE

Fig. 7

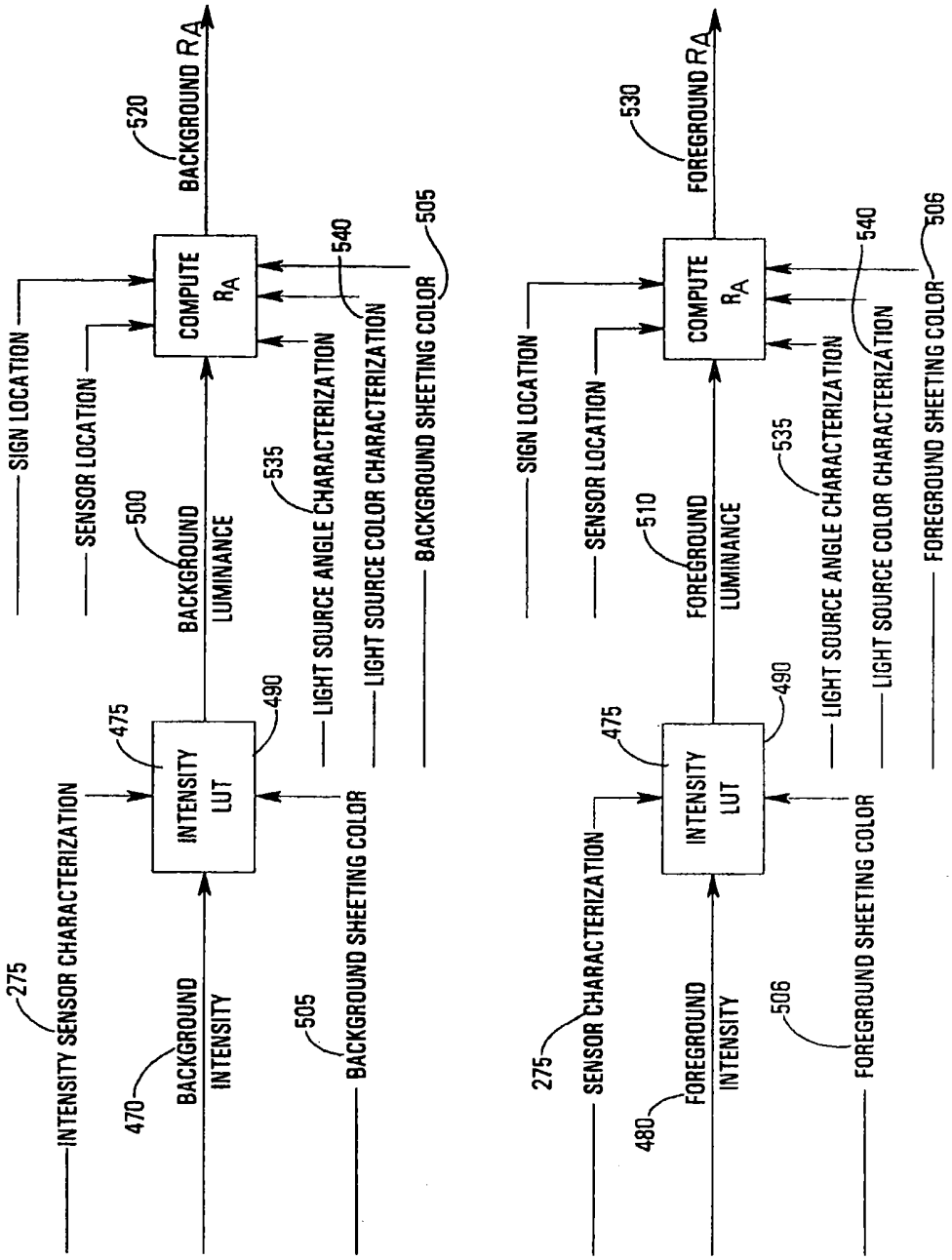

INTENSITY SENSOR CHARACTERIZATION
275
BACKGROUND INTENSITY
470
INTENSITY LUT
475
BACKGROUND SHEETING COLOR
505
490
BACKGROUND LUMINANCE
500
SENSOR LOCATION
SIGN LOCATION
LIGHT SOURCE ANGLE CHARACTERIZATION
535
LIGHT SOURCE COLOR CHARACTERIZATION
540
BACKGROUND SHEETING COLOR
505
COMPUTE R_A
BACKGROUND R_A
520
SENSOR CHARACTERIZATION
275
FOREGROUND INTENSITY
480
INTENSITY LUT
475
FOREGROUND SHEETING COLOR
506
490
FOREGROUND LUMINANCE
510
SENSOR LOCATION
SIGN LOCATION
LIGHT SOURCE ANGLE CHARACTERIZATION
535
LIGHT SOURCE COLOR CHARACTERIZATION
540
FOREGROUND SHEETING COLOR
506
COMPUTE R_A
FOREGROUND R_A
530

Fig. 8

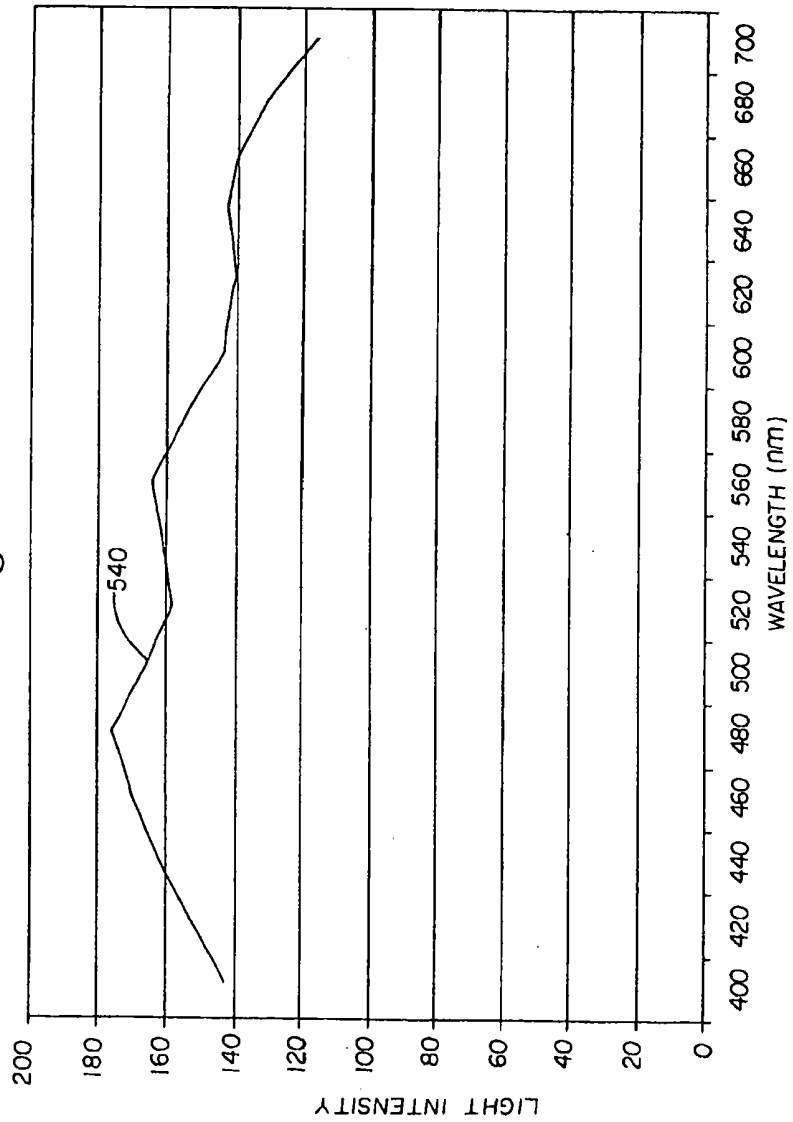

540
LIGHT INTENSITY
200
180
160
140
120
100
80
60
40
20
0
400
420
440
460
480
500
520
540
560
580
600
620
640
660
680
700
WAVELENGTH (nm)

Fig.9

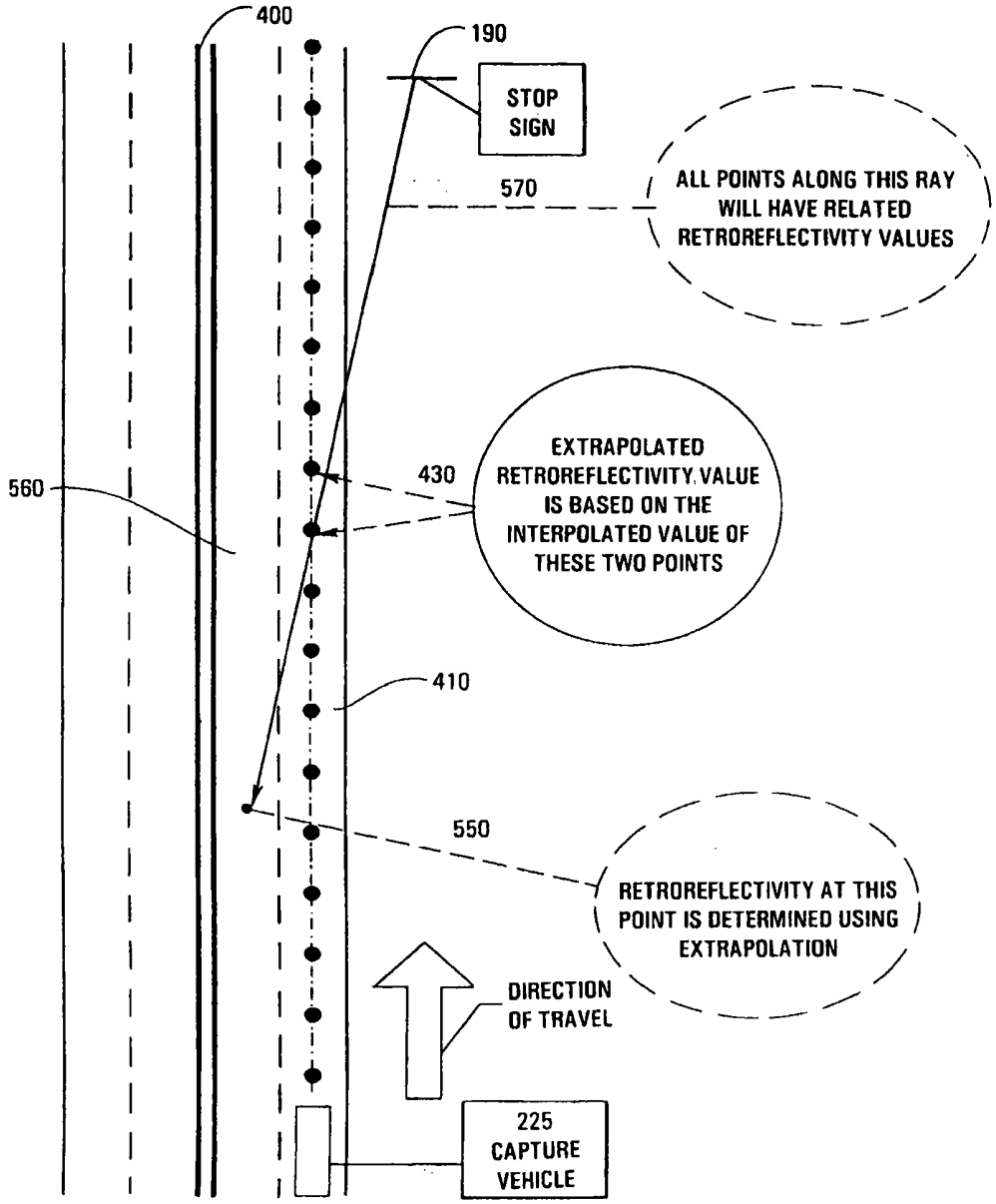
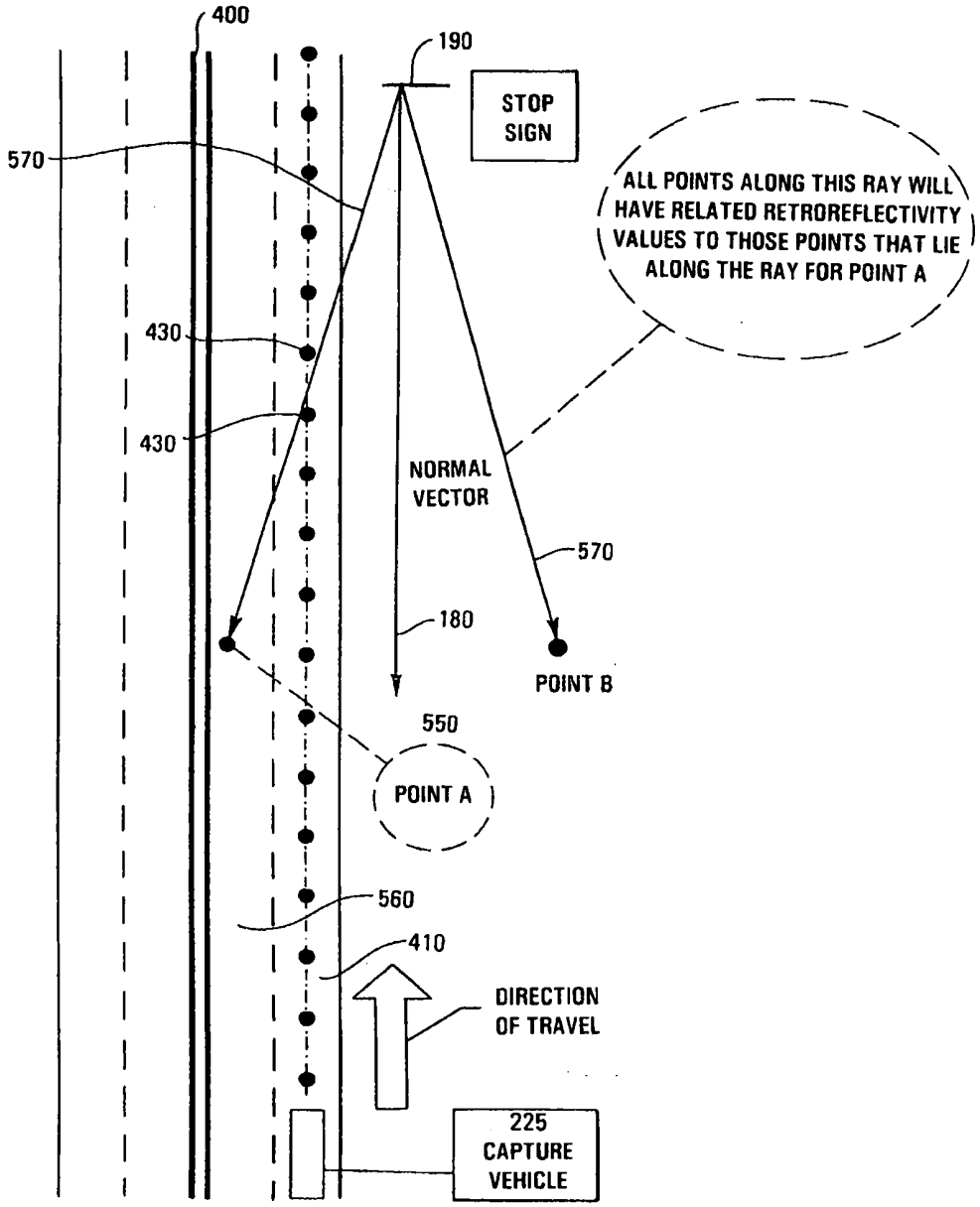

400
190
STOP SIGN
570
ALL POINTS ALONG THIS RAY WILL HAVE RELATED RETROREFLECTIVITY VALUES
560
430
EXTRAPOLATED RETROREFLECTIVITY VALUE IS BASED ON THE INTERPOLATED VALUE OF THESE TWO POINTS
410
550
RETROREFLECTIVITY AT THIS POINT IS DETERMINED USING EXTRAPOLATION
DIRECTION OF TRAVEL
225 CAPTURE VEHICLE

Fig.10


400
190
STOP SIGN
570
ALL POINTS ALONG THIS RAY WILL HAVE RELATED RETROREFLECTIVITY VALUES TO THOSE POINTS THAT LIE ALONG THE RAY FOR POINT A
430
430
NORMAL VECTOR
570
180
POINT B
550
POINT A
560
410
DIRECTION OF TRAVEL
225 CAPTURE VEHICLE

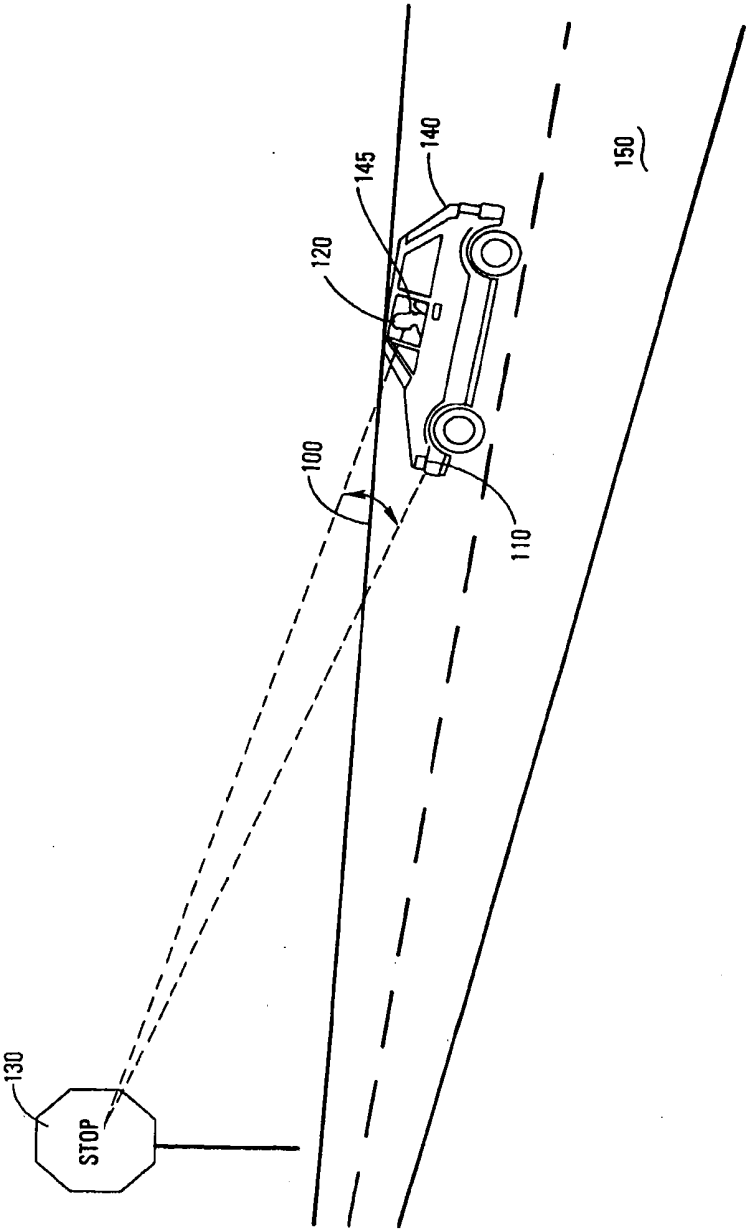


Fig. 11

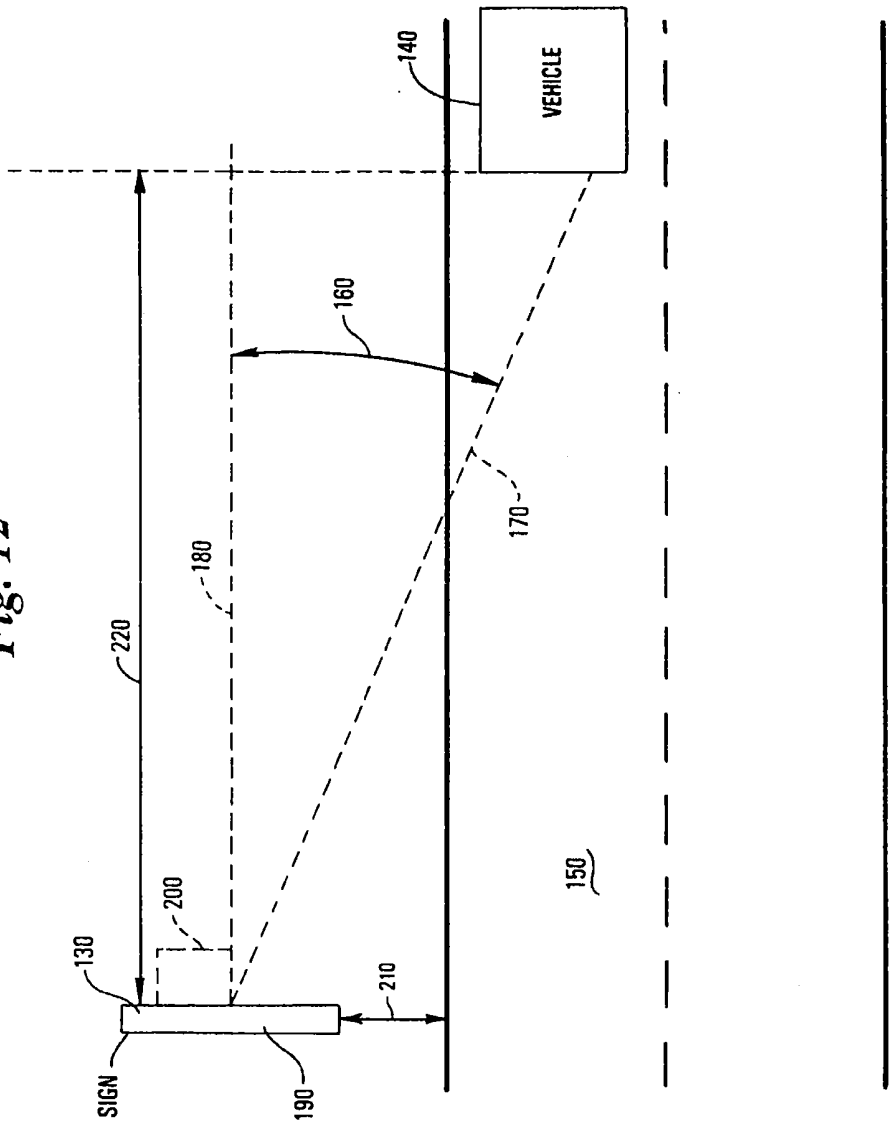


Fig. 12

Fig. 13

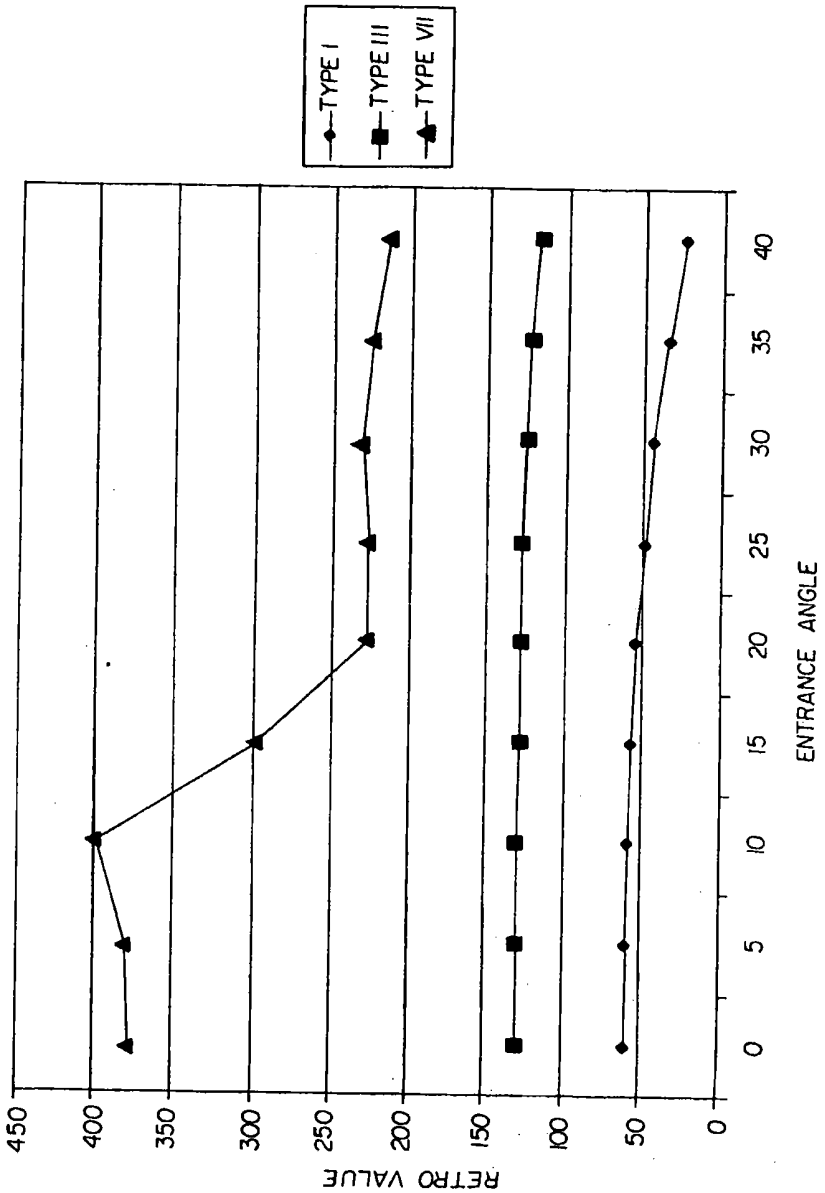

TYPE I
TYPE III
TYPE VII
RETRO VALUE
450
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
ENTRANCE ANGLE

Fig.14A

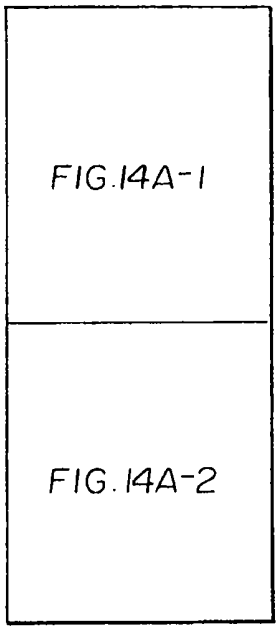


Fig.14B

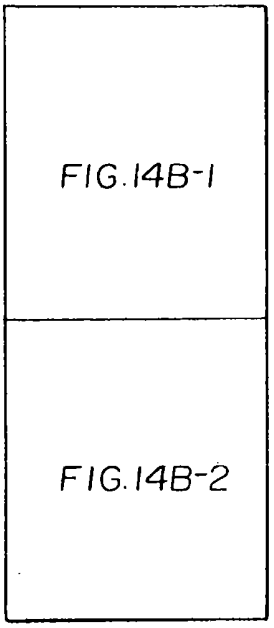


Fig.14A-1

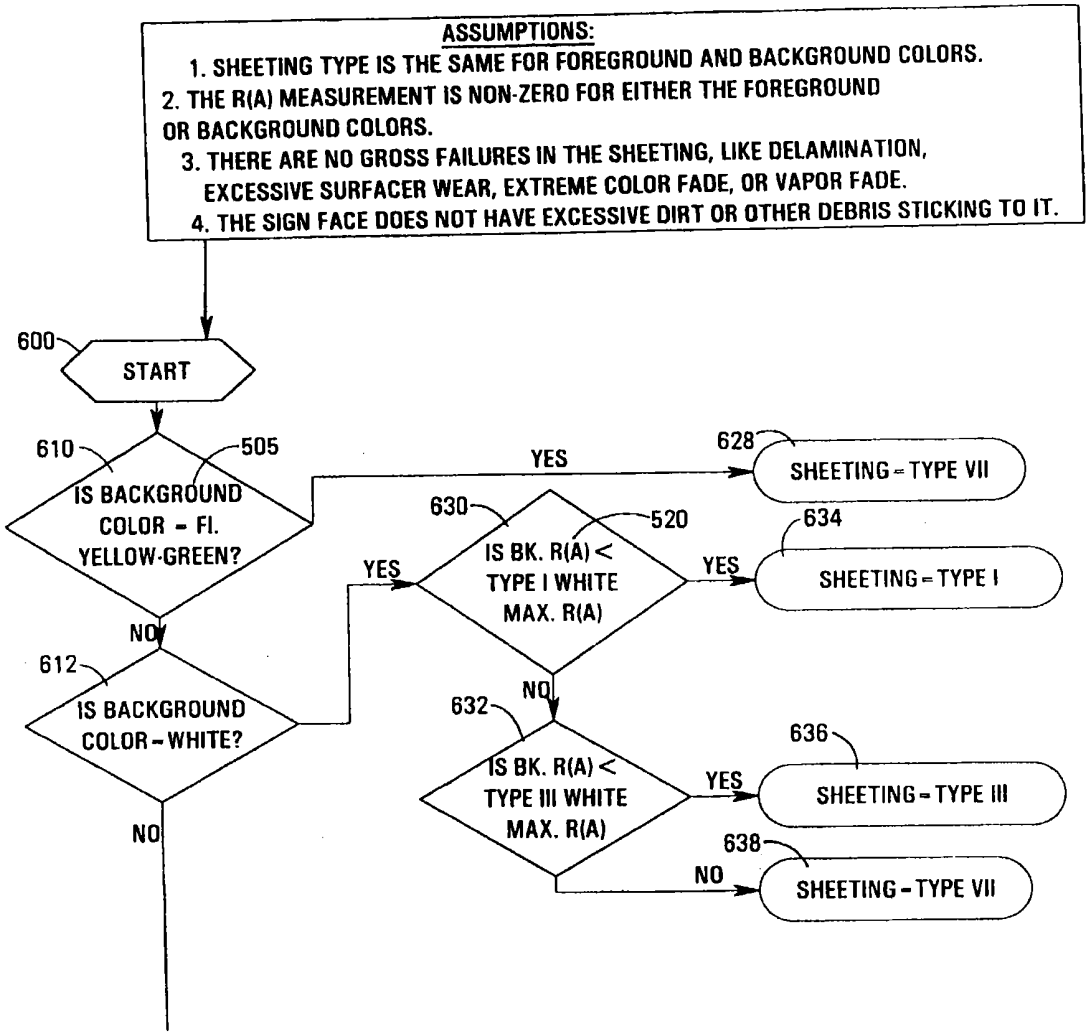

ASSUMPTIONS:
1. SHEETING TYPE IS THE SAME FOR FOREGROUND AND BACKGROUND COLORS.
2. THE R(A) MEASUREMENT IS NON-ZERO FOR EITHER THE FOREGROUND OR BACKGROUND COLORS.
3. THERE ARE NO GROSS FAILURES IN THE SHEETING, LIKE DELAMINATION, EXCESSIVE SURFACER WEAR, EXTREME COLOR FADE, OR VAPOR FADE.
4. THE SIGN FACE DOES NOT HAVE EXCESSIVE DIRT OR OTHER DEBRIS STICKING TO IT.
600
START
610
505
IS BACKGROUND COLOR = Fl. YELLOW-GREEN?
YES
628
SHEETING = TYPE VII
NO
612
IS BACKGROUND COLOR = WHITE?
YES
630
520
IS BK. R(A) < TYPE I WHITE MAX. R(A)
YES
634
SHEETING = TYPE I
NO
632
IS BK. R(A) < TYPE III WHITE MAX. R(A)
YES
636
SHEETING = TYPE III
NO
638
SHEETING = TYPE VII
NO

Fig.14A-2

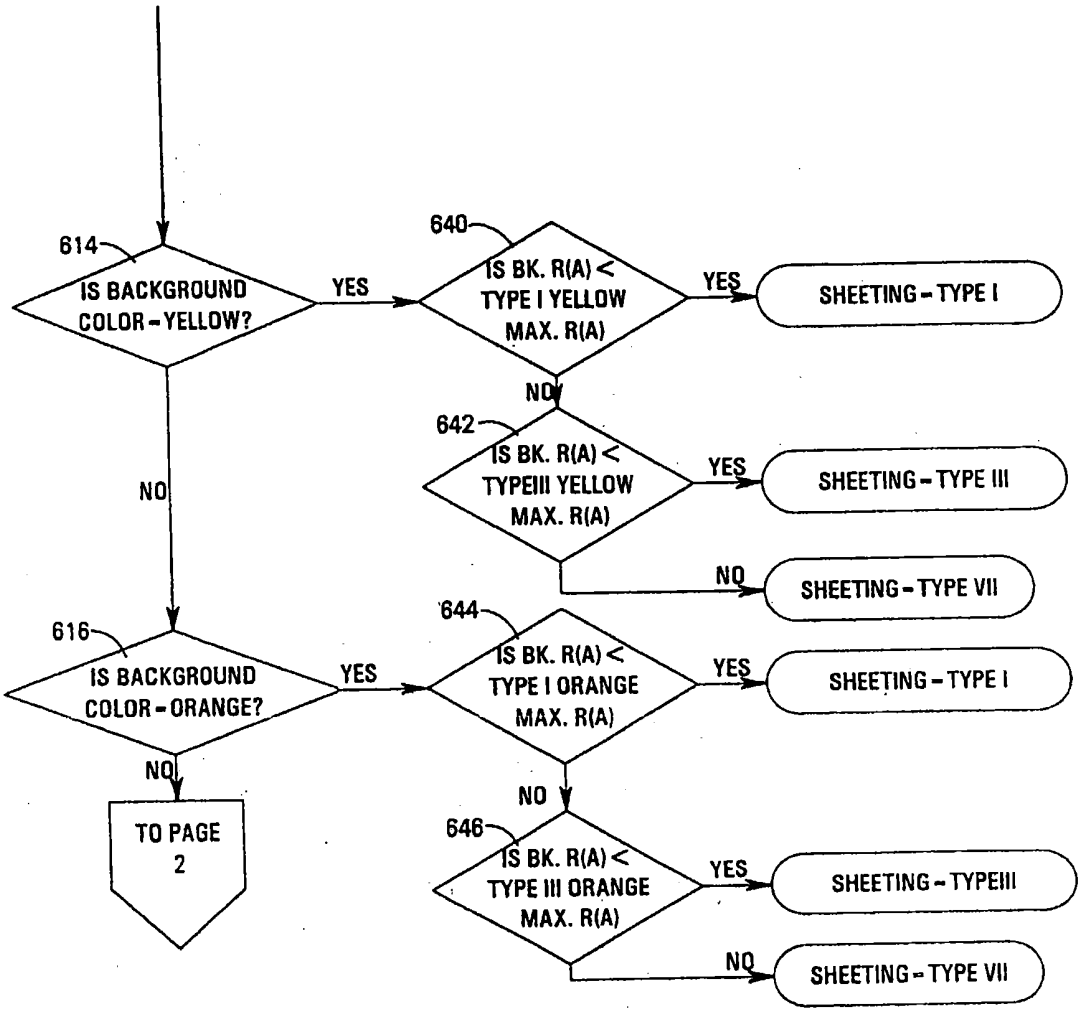

614
IS BACKGROUND COLOR - YELLOW?
YES
NO
640
IS BK. R(A) < TYPE I YELLOW MAX. R(A)
YES
SHEETING - TYPE I
NO
642
IS BK. R(A) < TYPEIII YELLOW MAX. R(A)
YES
SHEETING - TYPE III
NO
SHEETING - TYPE VII
616
IS BACKGROUND COLOR - ORANGE?
YES
NO
TO PAGE 2
644
IS BK. R(A) < TYPE I ORANGE MAX. R(A)
YES
SHEETING - TYPE I
NO
646
IS BK. R(A) < TYPE III ORANGE MAX. R(A)
YES
SHEETING - TYPEIII
NO
SHEETING - TYPE VII

Fig.14B-1

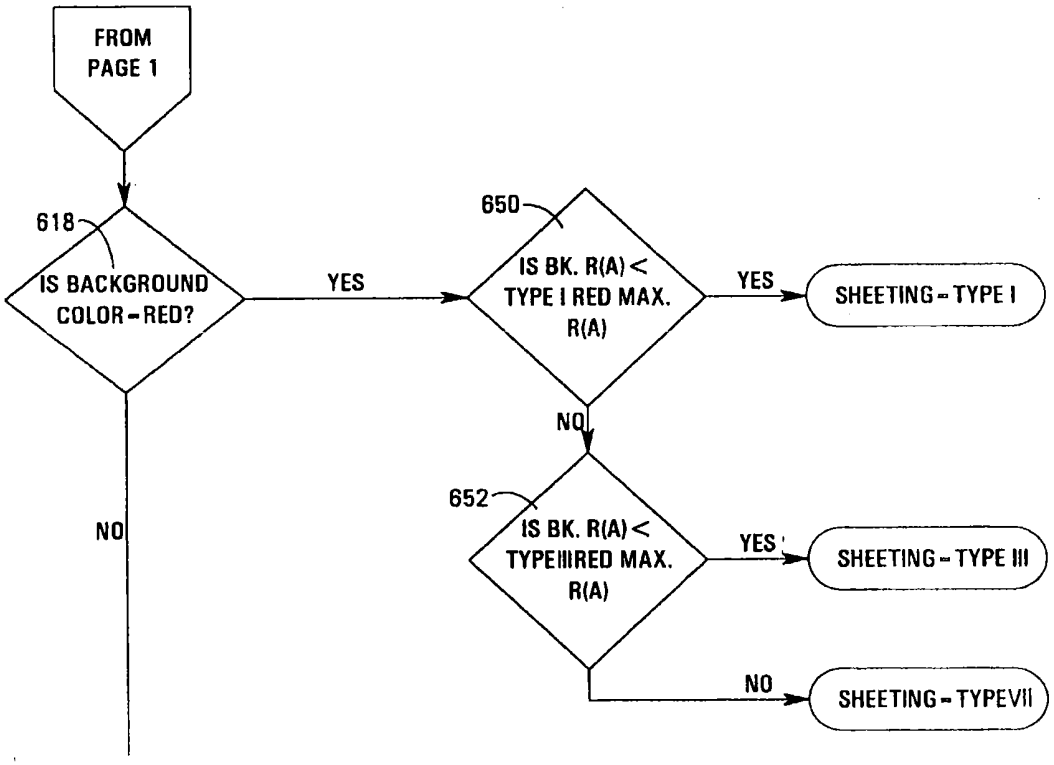
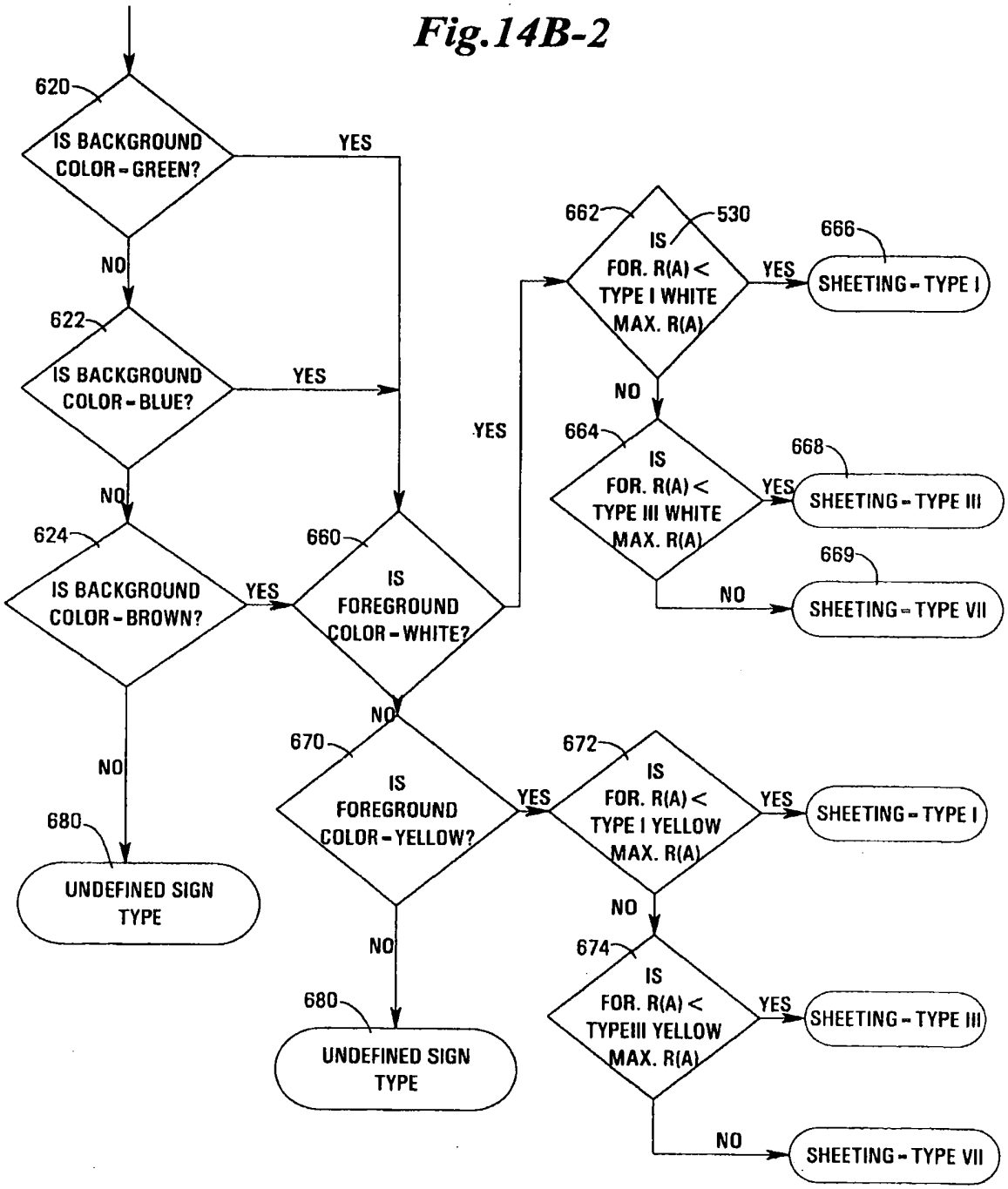

FROM
PAGE 1
618
IS BACKGROUND
COLOR = RED?
YES
NO
650
IS BK. R(A) <
TYPE I RED MAX.
R(A)
YES
SHEETING - TYPE I
NO
652
IS BK. R(A) <
TYPE III RED MAX.
R(A)
YES
SHEETING - TYPE III
NO
SHEETING - TYPE VII

Fig.14B-2


620
IS BACKGROUND COLOR = GREEN?
YES
NO
622
IS BACKGROUND COLOR = BLUE?
YES
NO
624
IS BACKGROUND COLOR = BROWN?
YES
NO
680
UNDEFINED SIGN TYPE
660
IS FOREGROUND COLOR = WHITE?
YES
NO
662
530
IS FOR. R(A) < TYPE I WHITE MAX. R(A)
YES
666
SHEETING = TYPE I
NO
664
IS FOR. R(A) < TYPE III WHITE MAX. R(A)
YES
668
SHEETING = TYPE III
NO
669
SHEETING = TYPE VII
670
IS FOREGROUND COLOR = YELLOW?
YES
NO
680
UNDEFINED SIGN TYPE
672
IS FOR. R(A) < TYPE I YELLOW MAX. R(A)
YES
SHEETING = TYPE I
NO
674
IS FOR. R(A) < TYPEIII YELLOW MAX. R(A)
YES
SHEETING = TYPE III
NO
SHEETING = TYPE VII

SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

RELATED APPLICATIONS

The present application is a divisional of U.S. Application No. 13/205,337, filed August 8, 2011, which is a divisional of U.S. Application No. 12/419,843, filed April 7, 2009, which is a continuation of Application No. 11/056,926, filed February 11, 2005, now U.S. Patent No. 7,515,736, which is a continuation of Application No. 09/928,218, filed August 10, 2001, now U.S. Patent No. 6,891,960, which claims the benefit of the contents and filing date accorded to two U.S. Provisional Patent Applications, the first of which was filed on August 12, 2000 as Application No. 60/224,761, and the second of which was filed on June 7, 2001 as Application No. 60/296,596. The application is related to U.S. Patent No. 6,674,878, issued January 6, 2004, and U.S. Patent No. 6,453,056, issued September 17, 2002, which is a continuation of U.S. Patent No. 6,266,442, filed October 23, 1998, all of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to the field of automated object recognition. More specifically, the present invention relates to a system for classifying different types of sheeting materials of road signs depicted in a videostream.

BACKGROUND OF THE INVENTION

The goal of using an automated image identification system to recognize road signs and traffic signs is well known. Various techniques have been proposed for the recognition of road

signs as part of a real-time automated vehicle navigation system. Due to the processing limitations imposed by a real-time environment, almost all of these techniques have involved template matching of shape and color. Given the wide variations in lighting and conditions, few if any of these systems provide accurate results.

Another use of automated road sign recognition is for the purpose of identifying and creating an accurate inventory of all road signs and traffic signs along a given street or highway. In one system as described in U.S. Patent No. 6,266,442, entitled, "METHOD AND APPARATUS FOR IDENTIFYING OBJECTS DEPICTED IN A VIDEOSTREAM," issued July 24, 2001 to Laumeyer et al., an acquisition vehicle equipped with video cameras and position identifying technology, such as global positioning satellite (GPS) receivers, is systematically driven over the roads and streets in a given area to produce a videostream tagged with location information. The tagged videostream is analyzed by computer software routines to perform object recognition of the desired objects, the road signs in this case. The results of this analysis are exported to an asset management database that stores attributes of the road signs.

Road signs are manufactured from a sheeting material made up of multiple layered films (one or more colored layers that are fused with a layer that produces the reflectivity) that is adhered to the sign face. There are different types of sheeting material utilized in the road sign industry. Currently, specific attributes about each road sign like retroreflectivity (measured in candelas/lux/sq. meter) and sheeting type must be gathered manually by sending personnel in the field to measure retroreflectivity with a handheld device (like the Impulse RM retro-reflectometer from Laser Technology, Inc.) and to visually determine the sheeting type of each sign. Measurements of retroreflectivity and identification of sheeting type are helpful in

evaluating the visibility of a sign and whether it has deteriorated due to a breakdown in the pigments or reflective material in the sheeting material of the sign. The retroreflectivity and sheeting type can also be used to produce a predictive model of how the sign will perform into the future based on the as-measured characteristics.

Generally, highway and street maintenance departments do not systematically evaluate the deterioration of the reflective materials used on road signs and markers. If inspections of road signs or markers are performed, they are typically accomplished by having inspectors manually position a handheld retroreflectometer directly on the surface of a sign in order to determine a retroreflectivity value for that sign. When there are a large number of road signs or markers (sometimes referred to as traffic control devices or TCDs) in a given jurisdiction, the task of manually inspecting all of these road signs and markers can be time consuming and expensive.

One technique for determining retroreflectivity, designated as "R_A" generally (and from time to time in this disclosure), which does not require that a retroreflectometer be placed directly on a sign is described in U.S. Patent No. 6,212,480 entitled, "APPARATUS AND METHOD FOR DETERMINING PRECISION REFLECTIVITY OF HIGHWAY SIGNS AND OTHER REFLECTIVE OBJECTS UTILIZING AN OPTICAL RANGE FINDER INSTRUMENT" issued April 3, 2001 to Dunne. The Dunne patent relates to a device commercialized by the assignee thereof and marketed as the "Impulse RM" retro-reflectometer by Laser Technology, Inc., of Englewood, Colorado, USA. In use, handheld devices fabricated according to the Dunne patent are manually directed toward, or precisely at, a target object and then manually "fired." Once fired, the handheld device bounces a laser off the target object and

measures the reflected laser energy that is then used to determine a retroreflectivity.

There are several drawbacks of the handheld laser arrangement described by the Dunne patent. The handheld device can only measure a single color at a time and can only measure one object at a time. The determination of retroreflectivity for a given object is valid only for the actual location, or discrete measurement point, along the roadway at which the measurement was made by the human operator. In order to validate a measurement made by such devices, the device must be taken back to the precise location in the field where an original measurement occurred for a valid comparison measurement to be made.

Another technique established for determining the retroreflectivity of signs has been introduced by the Federal Highway Administration (FHWA). The Sign Management and Retroreflectivity Tracking System (SMARTS) is a vehicle that contains one high intensity flash source (similar to the Honeywell StrobeGuard™ SG-60 device), one color camera, two black and white cameras, and a range-sensing device. The SMARTS vehicle requires two people for proper operation – one driver and one system operator to point the device at the target sign and arm the system. The SMARTS travels down the road, and the system operator "locks on" to a sign up ahead by rotating the camera and light assembly to point at the sign. At a distance of 60 meters, the system triggers the flash source to illuminate the sign surface, an image of which is captured by one of the black and white cameras. A histogram is produced of the sign's legend and background that is then used to calculate retroreflectivity. A GPS system stores the location of the vehicle along with the calculated retroreflectivity in a computer database.

Like the handheld laser device of the Dunne patent, the SMARTS device can only determine retroreflectivity for one sign at a time and can only determine retroreflectivity for the

discrete point on the roadway 60 meters from the sign. Two people are required to operate the vehicle and measurement system. The SMARTS vehicle cannot make retroreflectivity determinations for signs on both sides of the roadway in a single pass over the roadway, and does not produce nighttime sign visibility information for lanes on the roadway not traveled by the vehicle. Because the system operator in the SMARTS vehicle must locate and track signs to be measured while the vehicle is in motion, a high level of operational skill is required and the likelihood that a sign will be missed is significant. Most importantly for purposes of the present invention, the SMARTS device makes no attempt to automatically determine sheeting type of a sign.

There are an estimated 58 million individual TCDs that must be monitored and maintained in the United States and new TCD installations increase this number daily. For the reasons that have been described, the existing techniques for determining retroreflectivity do not lend themselves to increasing processing throughput so as to more easily manage the monitoring and maintenance of these TCDs. So called automated data collection systems often require that normal traffic be stopped during data collection because either the acquisition vehicle moved very slowly or because the acquisition vehicle had to come to a full stop before recording data about the roadside scene. Furthermore, a human operator is required to point one or more measurement devices at a sign of interest, perform data collection for that particular sign and then set up the device for another particular sign of interest. With such a large number of TCDs that must be monitored, it would be desirable to provide an automated system for determining the retroreflectivity of road signs and markers that addresses these and other shortcomings of the existing techniques to enable a higher processing throughput of an automated determination of

the retroreflectivity and sheeting classification of road signs and markers.

SUMMARY OF THE INVENTION

The present invention is a system for classifying different types of sheeting materials of road signs depicted in a videostream. 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.

In a preferred embodiment, a system for the automated determination of retroreflectivity values for reflective surfaces disposed along a roadway is utilized to establish the retroreflectivity values for both foreground and background colors of a road sign for the purpose of classifying the sheeting material of that sign. An area along the roadway that includes at least one reflective surface is repeatedly illuminated by a light source and multiple light intensity values are measured over a field of view which includes at least a portion of the area illuminated by the light source. A computer processing system is used to identify a portion of the light intensity values associated with a reflective surface and analyze the portion of the light intensity values to determine at least one retroreflectivity value for that reflective surface. Color images of the area and locational information are also generated by the system and are used together

with a characterization profile of the light source to enhance the accuracy of the determination of retroreflectivity values.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a capture vehicle used in a preferred embodiment of the present invention.

FIG. 2 is a data flow diagram of a preferred embodiment of the present invention.

FIG. 3 depicts a block diagram of the systems, subsystems and processes for capturing and processing roadside information from a moving platform in order to compute retroreflectivity according to the teaching of the present invention, wherein the arrows connecting the blocks of the diagram illustrate the connections between the systems and sub-systems for computing R_A for each reflective asset recorded by the system of the present invention.

FIG. 4 depicts in diagram form, a preferred configuration of a sensor suite for use with a four-wheeled vehicle and the interconnections and couplings between the physical

subcomponents of a system designed according to the present invention.

FIG. 5 is a plan view of a divided multi-lane vehicle pathway and depicts how periodic light intensity measurements may be made as a vehicle traverses the vehicle pathway over time and the discrete locations where such periodic light intensity measurements are performed by a data acquisition vehicle operating in accordance with the present invention.

FIG. 6 depicts four digital frames of data as captured by the intensity sensor at various discrete locations along the vehicle pathway depicted in FIG. 5.

FIG. 7 depicts a flowchart showing the steps required to convert intensity measurements into foreground and background retroreflectivity for a single reflective asset.

FIG. 8 depicts a typical light source intensity profile over the visible electromagnetic spectrum, which illustrates how different wavelengths of electromagnetic radiation possess different light intensities.

FIG. 9 depicts a preferred methodology for creating a retroreflectivity profile for all lanes and locations adjacent a vehicle pathway for a single reflective asset or sign which retroreflectivity profile is based upon a single pass of a data acquisition vehicle over the vehicle pathway.

FIG. 10 illustrates the facts that the normal vector of a reflective asset and the sheeting type of such a reflective asset create symmetry that may be used to determine retroreflectivity values along all rays (or vectors) that have the same relative angle to the normal vector of the reflective asset.

FIG. 11 depicts the concept of observation angle (i.e., angle between incident light from a light source and an human observer (or light sensor), of the light as reflected from the face of a

reflective asset) in the context of a conventional passenger vehicle traversing a vehicle pathway and where light from the vehicle reflects from a stop sign to the vehicle operator (shown in ghost).

FIG. 12 depicts the concept of entrance angle (i.e., angle between incident light from a light source mounted to a vehicle and a normal vector relative to the substantially flat face of a reflective surface disposed adjacent a vehicle pathway).

FIG. 13 is a graphic representation of the retroreflectivity performance for white sheeting for the three main types of sign sheeting.

FIGS. 14A and 14B depict a flowchart for a preferred embodiment of the threshold algorithm used to determine sign sheeting type.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, an acquisition vehicle 10 is equipped with multiple video cameras 12 that generate a series of raw videostreams 14 representative of a road or street over which the acquisition vehicle 10 is traveling. A global positioning satellite (GPS) receiver 16 supplies location information that is combined with the raw videostream 14 by a processor 18 to generate a tagged videostream 20.

In one embodiment as shown in FIG. 2, the tagged videostream 20 is analyzed by a computer processor 22 to identify each road sign 30 and generate an asset management database 24 containing attribute and location information associated with each road sign 30. In an alternate embodiment, the identification of road signs 30 and generation of asset management database 24 is accomplished by the same processor 18 that tags the raw videostream 14. The

details of this process are set out in U.S. Patent No. 6,453,056, issued September 17, 2002 to Laumeyer et al., which is hereby incorporated by reference.

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 be the reference values used in the threshold algorithm from which sign sheeting classification will be determined.

There are three main types of sheeting recognized in the industry: 1) Type I, commonly called Engineer Grade; 2) Type III, commonly called High Intensity; and 3) Type VII, commonly called Prismatic (Prismatic is sometimes divided into two groups – Type VIIa called Diamond Grade VIP, and Type VIIb called Diamond Grade LDP). In order to remove the manual element of determining sheeting type and measuring retroreflectivity, the automated system of the present invention must accurately distinguish between these sheeting types. To accomplish this, the present invention utilizes the fact that all signs use the same sheeting type for foreground and background colors, that each road sign will have at least two colors and that

the reflectivity for each color for each type of sheeting material has a relatively unique minimum initial retroreflectivity value. Most signs also have either White, Yellow or Orange colors as one of the colors on the sign. According to 3M, a manufacturer of reflective sheeting material, each color of the three sheeting types has a minimum initial retroreflectivity value. The following table lists the minimum values for common colors of each type:

Color	Type I Min.R_A	Type III Min.R_A	Type VIIa Min.R_A	Type VIIb Min.R_A
White	70	250	430	800
Yellow	50	170	350	660
Orange	25	100	200	360
Red	14.5	45	110	215
Green	9	45	45	80
Blue	4	20	20	43

This information is stored in a reflectivity/color database 50. The computer processor 22 accesses the database 50 using the maximum reflectivity value 44, 46 that corresponds to the color value 40, 42 for each color portion 34, 36 to determine the lowest possible sheeting type for each color. If the sheeting type is classified the same for all of the color portions 34, 36 for a given road sign 30, then the sheeting class 52 is established as that type and this information is preferably stored in the asset management database 24 along with other attributes of the given road sign 30. If there is a discrepancy in the classification of sheeting material between different colors, a subsequent analysis by the processor 22 using, for example, a neural network program,

to incorporate other determining factors, such as time of day, shadow, direction that could affect the retroreflectivity of the lighter colors (white, yellow and orange) more than the retroreflectivity of the darker colors (red, green, blue). In general, retroreflectivity values for lighter colors are weighted more heavily in resolving any discrepancies in classification of sheeting material.

The system described herein acquires many data points along the desired roadway without specifically targeting any objects of interest. For a roadside sign, the specific geometry of the sign (its orientation with respect to the roadway) is not necessarily known, nor is it required. The retroreflectivity points determined along the roadway are generated for the "as placed" road sign. Road signs will display their best retroreflectivity performance (have the highest retroreflectivity values) at or near the normal vector for the sign face. Since the geometry of the as-measured sign is not known, the system chooses the highest retroreflectivity value for that sign as the value that will be used in the threshold algorithm for sign sheeting classification.

There are several factors that can cause retroreflectivity readings for signs to actually be lower than the values for the underlying sheeting type. For example, a sign that has a layer of dirt on the face will produce lower retroreflectivity numbers than usual. If these lower numbers are used in the threshold comparison algorithm, an incorrect sheeting type may result. These systematic errors can be removed by analyzing the retroreflectivity profile for the sign.

Sign sheeting types vary by the intensity of light that is reflected, but they also have reflective characteristics that give them unique signatures. Fig. 13 shows the profiles for Type I, Type III, and Type VII white sign sheeting types. Note the unique profiles for the three sheeting

types. The preferred embodiment of the present invention, due to its ability to utilize multiple retroreflectivity points, can determine sheeting type by matching the as-measured profile with a uniformly reduced (where the entire curve is multiplied by a scaling factor that is less than one) characteristic curve that best correlates to the as-measured profile. This correlation step will establish the "best fit" performance curve based on the shape of the curve, without consideration for the magnitude of the curve. This "uniform reduction" of the sign sheeting performance curve allows the proper sheeting type to be determined, thus overcoming the problem with signs that have some type of surface anomaly. The performance curve correlation described above can be used in one of two ways – either as a validation of the proper determination of sheeting type from the threshold algorithm or as one of the qualification criteria prior to performing the threshold algorithm.

The sheeting types are all manufactured with multiple layers. In order for the present invention to accurately compute retroreflectivity for purposes of determining sheeting type of a given road sign, it is also necessary for the system to recognize gross sheeting failures like extreme color fade, de-lamination and vapor fade (darkening of the daylight appearance of the sheeting due to the corrosion of the metal sign backing). These gross failures will impact R_A measurements of the sheeting. Preferably, the sheeting determination system described herein tests for the absence of these gross failures prior to making any R_A measurements as part of the process of categorizing sheeting type.

Retroreflectivity, designated as "R_A" generally (and from time to time in this disclosure), varies according to two key parameters, observation angle and entrance angle. Observation angle 100 (See FIG. 11) is the angular displacement between a light source 110 and a light

sensor 120, as measured from an object face surface 130. In the case of a vehicle 140 driven by vehicle operator 145 moving along a highway 150, observation angle 100 is defined by the distance of the vehicle 140 from a sign face surface 130, the placement of the light source (headlights) 110 on the vehicle 140, and the position of the light sensor (eyes of the vehicle operator) 120 of the vehicle 140.

Entrance angle 160 (See FIG. 12) is defined as the angular displacement of the incident light 170 relative to the normal vector 180 from the object face surface 130. Entrance angles are impacted by the angular position 200 of a sign 190 relative to the highway 150, the sign 190 lateral distance 210 from the highway 150, and the distance 220 of the vehicle 140 from the sign 190. The inventors hereof are believed to be the first persons to successfully decrease the complexity and increase the efficiency of determination of R_A in the field.

The method of automated determination of R_A (See FIGS. 3 and 4) preferably utilizes a plurality of subsystems located on/in a capture vehicle 225. These subsystems include a light intensity measurement system 230, a vehicle positioning system 240, a color image capture system 250 and a data recording system 260. The light intensity measurement system 230 preferably includes a high output light source 270, a light intensity sensor 280 and an intensity measurement system control 290. A plurality of intensity measurements 300 are generated by the intensity measurement system 230 in response to the repeated strobing of the high output light source 270. The vehicle positioning system 240 preferably includes a GPS receiver 310, an inertial navigation system 320, a distance measuring instrument 330 and a master clock 340. A position measurement 350 is generated by the vehicle positioning system 240. The color image capture system 250 preferably includes a stereoscopic camera pair 360, iris controls 370 and

image capture control 380. The image capture system 250 generates a digital imagery stream 390.

The data required for the automated determination of R_A is accumulated while traversing a highway 150 with the capture vehicle 225 (See FIGS. 5 and 6). The capture vehicle 225 is shown on a 4-lane divided highway 400 with the capture vehicle 225 located in a proximate lane 410 to the stop sign 190. Preferably, a series of reflected light intensity frames 420 are generated at a constant measurement interval 430 as the capture vehicle travels along the highway 150.

Characterization of sign 190 R_A preferably utilizes the data recording system 260 to create a single tagged videostream 440 from the reflected light intensity frames 420, position measurements 350 and digital imagery 390 for each capture event 430 (See FIGS. 3, 5, 6, 7, and 8). A computer processor 450 identifies an object of interest 460 in a portion of the intensity frame 420 and determines the object of interest attributes 465 associated with that object of interest. Preferably, the objects of interest are identified from the digital imagery stream 390 generated by the color image capture system 250 in the manner as taught by U.S. Patent No. 6,266,442. Alternatively, other techniques known in the art for isolating an object of interest in a videostream can be used. 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.

For each object of interest 460, a background intensity measurement 470 and a foreground intensity measurement 480 is generated. Using an intensity algorithm 490, a light intensity sensor characterization 275 and a look-up-table 475, the computer processor 450 determines a background luminance value 500 and a foreground luminance value 510. Based on

the background luminance value 500, the foreground luminance value 510, a characterization of light source wavelength 540, the background sheeting color 505 and the foreground sheeting color 506 the computer processor 450 characterizes a background R_A 520 and a foreground R_A 530 which are preferably reported separately for that object of interest.

The automated determination of multiple R_A values for a given object of interest 460 allows for the extrapolation of R_A values at an unmeasured viewing point 550 for an object of interest, such as a sign 190 (See FIGS. 9 and 10). In this example, the unmeasured viewing point resides in a nontraversed lane 560. The computer processor 450 defines an undetermined retroreflectivity ray 570 for unmeasured viewing point 550. Using interpolated values, the computer processor 450 determines an R_A value for unmeasured viewing point 550 and any point located along undetermined retroreflectivity ray 570.

Pursuant to the teaching of the present invention, a method and apparatus for determining retroreflectivity of relatively flat surface portions of objects disposed adjacent a highway 150 traversed by a vehicle 140 are taught, enabled, and depicted. The present invention may be utilized to detect and determine a retroreflective surface of interest disposed in a scene of non-retroreflective surfaces. That is, at least one object face surface 130 which exhibits retroreflectivity over at least a relatively narrow conical volume of magnitude of several degrees from a normal vector 180 originating from said object face surface 130.

In accordance with the present invention, a determination of the retroreflectivity of objects adjacent a highway 150 preferably includes providing: (i) position measurements 350 of a capture vehicle 225; (ii) precise position of the object of interest 460, or sign 190; (iii) intensity measurements 300 from a high output light source 270 and light intensity sensor 280 at

measurement intervals 430 along said highway 150. Thus, a single-pass along the highway 150 by the capture vehicle 225 operating the light intensity measurement system 230, vehicle positioning system 240, image capture system 250 and data recording system 260 taught herein eliminates many shortcomings of the prior art and allows a single vehicle operator to conduct virtually continuous data measurement and acquisition of objects of interest 460 disposed adjacent a highway 150, at capture events 430 on said highway 150, without disrupting or interrupting other vehicle traffic traversing said highway 150.

FIG. 3 shows a block diagram of the on-board systems and the desktop systems required to record a tagged videostream 440 and create sign R_A profiles 590 for various signs 190 along a highway 150. The vehicle positioning system 240 contains all of the equipment to precisely locate the capture vehicle 225. All location information is synchronized with a master clock 340 preferably associated with a computer processor 450, which allows other data types to be merged with the vehicle location information at later stages in the post-processing. All of the on-board systems utilize the same master clock 340 information, thus allowing any events (image capture system 250, intensity measurement 300, and trigger controls 227, 228) to be correlated to the precise vehicle location and attitude during real-time, near real-time, or post-processing of the data acquired by the capture vehicle 225.

The image capture system 250 consists of at least one set of stereoscopic cameras 360 that gather digital imagery along the highway 150. Each capture event is combined with time stamp information from the vehicle positioning system 240 which also provides trigger control 227 for the image capture system 250 and trigger control 228 for the light intensity measurement system 230. These images and associated time stamps are later combined with photogrammetry

to create objects of interest 460 and their associated attributes 465.

The light intensity measurement system 230 preferably consists of at least one high output light source(s) 270 and the associated light intensity sensor(s) 280. The precise control for these items is contained within the light intensity measurement system 230, and master time sequencing instrument 340 information received from the vehicle positioning system 240 (or computer processor 450) is combined to create a tagged videostream 440 so precise vehicle information can be utilized during post-processing.

The data recording system 260 is constantly monitoring control information from the other three on-board systems and records the necessary information. No post-processing is performed in the data recording system 260. As computer power increases in the future, one skilled in the art could produce a system whereby most, if not all, of the post-processing functions were performed in the capture vehicle 225, perhaps even in real time. The inventors can imagine several uses for the production of real-time information from the image capture system 250 in the future, but the cost of obtaining such information with today's computing power makes this option prohibitively expensive today.

The lower half of FIG. 3 shows the functional blocks for data post-processing. There are two main functions – the creation of objects of interest 460 and their associated attributes 465, and the determination of retroreflectivity for each object of interest 460. There are many methods for creating objects of interest 460 from digital imagery, a few of which are discussed in this disclosure. The specific steps required to compute R_A are outlined in the discussion below.

Fig. 4 shows a typical configuration within a capture vehicle that is capable of producing data and imagery to create digital representations of objects of interest 460 and objects of interest

retroreflectivity 466. The distance measuring instrument (DMI) 330, GPS receiver 310 and inertial navigation system (INS) 320 constitute the vehicle positioning system 240. Not all of these components are necessary to obtain the desired results, but better precision, and therefore more meaningful data, are produced if all three components are included.

The high output light source(s) 270 and light intensity sensor(s) 280 constitute the light intensity measurement system 230. These components make it possible to gather on-the-fly information for a desired highway 150 to allow the computation of object of interest retroreflectivity 466, as well as create a full 3-D sign R_A profile 590 for those same objects of interest 460.

The stereoscopic cameras 360 constitute the digital imagery system 390 that allows for the creation of objects of interest 460 and their associated attributes 465 during post-processing. More than one set of stereoscopic cameras 360 can be employed, thus increasing the accuracy of positional measurements for objects of interest 460. Other, non-stereoscopic imaging systems could also be employed with little or no change to the vehicle positioning system 240 or to the light intensity measurement system 230.

FIG. 5 shows the top view of a 4-lane divided highway 400 with a stop sign 190. The capture vehicle 225 is traveling in the proximate lane 410 to the stop sign 190 and makes intensity measurements 300 at capture events 430 while traveling the depicted route. The techniques described herein will allow a retroreflectivity value for this stop sign 190 to be computed for any point along the 4-lane divided highway 400, independent of whether the intensity measurement 300 was made at that point and also independent of whether the capture vehicle 225 actually drove over that point.

It should be noted that intensity measurements 300 are made continuously while the capture vehicle 225 is in motion, thus requiring no prior knowledge of either the positions or the existence of signs.

FIG. 6 shows some typical reflected light intensity frames 420 as captured by the light intensity sensor 280 at various discrete locations along the roadway. These reflected light intensity frames 420 are the result of the high output light source 270 being energized (or flashed) while each reflected light intensity frame 420 is captured by one or more light intensity sensors 280. Since most of the objects in the scene are not reflective, and due to the high setting of the threshold range in the light intensity sensor(s) 280, the reflected light intensity frames 420 will actually show very few objects. For effective luminance results throughout a wide range of retroreflective materials, more than one light intensity sensor 280 may be required in order to get enough levels of gray within the active part of the visible spectrum. When multiple light intensity sensors 280 are required or used, they may each have different threshold ranges and each thus detect luminance values in different parts of the desired luminance ranges.

In order to compute retroreflectivity (R_A), one needs to know the luminance of the reflected energy. Luminance (expressed in candelas per square meter, or cd/m^2) will vary according to the intensity sensor characterization profile 275 of the light intensity sensor(s) 280 and the color of the material from which light is reflected.

Most roadway signs 190 contain text and/or symbols overlaid on a background. To ensure maximum visibility during day and night conditions, the colors of the foreground information (text and/or symbols) are chosen to have maximum day and night contrast with the background material. The techniques taught herein allow the retroreflectivity of roadway signs

190 to be determined for both foreground and background materials. Computing both the foreground 530 and background retroreflectivity 520 for each object of interest 460 allows us to ensure that the proper nighttime contrast is achieved for roadside assets. For example, a stop sign 190 with a red background and white lettering can provide good daytime contrast between the text and the sign background. But if these two materials display very similar retroreflectivity characteristics, their nighttime contrast will be minimal, thus rendering the sign ineffective during nighttime conditions.

FIG. 7 shows a block diagram of the steps required to transform intensity measurements 300 into foreground luminance values 510 and background luminance values 500. First, a black and white camera is preferably used as a light intensity sensor 280 to maximize the sensitivity of intensity measurements 300 (intensity will be determined from the gray value of the corresponding pixels). Think of an intensity measurement 300 as intensity values for N discrete points within the scene, where N corresponds to the number of pixels in the light intensity sensor's 280 array. For a light intensity sensor 280 that has a resolution of 640x480 pixels, there are 307,200 discrete intensity values for each intensity sensor measurement 300. Although the preferred embodiment utilizes an intensity sensor measurement 300 in the form of an array of discrete pixel intensity values, preferably a single pixel intensity value is selected and utilized for the automated determination of a corresponding retroreflectivity value. Alternatively, an average or other combination of a group of pixel intensity values could be utilized for the automated determination of a corresponding retroreflectivity 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 intensity sensor characterization 275 is empirical information about the light intensity sensor 280 that is used to create the LUT 475. The same LUT 475 is used for computing foreground 510 and background luminance values 500.

The reader should note and appreciate that luminance is strictly a measure of the reflected light, while retroreflectivity (or R_A, expressed in candelas/lux/m^2) is a measure of the reflected light with respect to the incident light for that object. FIG. 7 shows the information needed to accurately convert luminance to R_A: sensor location, object location, light source characterization, and color of reflective material. For less precise R_A computations, a subset of the aforementioned characteristics can be utilized. For example, if a uniform light source (equal intensity throughout the scene), columnated light reflected from the surface of the object of interest 460, and a known distance 220 between the object of interest 460 and the light intensity sensor 280 are all assumed, then the sheeting color and luminance value may be used to determine a rough approximation (within 20%, for example) for R_A.

To obtain the highest quality R_A calculations, all of the data shown in FIG. 7 should be

utilized. The characterization of light source angle defines the amount of light emitted from the high output light source 270 throughout the source's field of view. Due to the limitations of lamp design and their associated reflectors, most semi-uniform light sources will have their greatest intensity at or near the normal vector for the light source. Since the high output light source(s) 270 are not aimed at objects of interest 460, the part of the incident light beam that is striking the object of interest 460 when the intensity measurement 300 is captured must be determined. Light source angle characterization is a process whereby empirical data from the light is modeled to establish the light intensity for numerous discrete vectors from the center of the light. When intensity values are determined for a discrete point in the scene (from the object's face surface 130), the light intensity sensor 280 location and heading, as well as the object of interest 460 location, are used to determine which light vector emanating from the light source was responsible for the resulting intensity measurement. The characterization of light source angle therefore, is a look-up-table where an object of interest's 460 angular displacement from the normal vector 180 for the high output light source 270 is converted to a light intensity for the associated vector.

Since the beam from the high output light source 270 is diverging, objects of interest 460 farther from the origin of the light will receive less incident radiation than those objects of interest 460 closer to the light. The characterization of light source angle is constructed at a few discrete distances from the light. Simple geometry can be used to compute the incident radiation (using an interpolation method for an actual distance between two discrete distances in the characterization of light source angle) hitting the actual object of interest 460 based on the empirical data from the characterization of light source angle.

The preferred high output light source 270 is a uniform full-spectrum (visible spectrum) light. In practice, this light source will not emit the same intensity for all wavelengths of visible light. One variable of light source color characterization that should be considered is the output profile of the light throughout the visible spectrum. FIG. 8 shows a typical full-spectrum light source output profile. Note that the intensity in the blue area (400-500 nm) of the spectrum is stronger than in the red area (600-700 nm). This profile specifies the amount of light energy (number of photons) emitted for a given frequency. Since R_A depends on the intensity of the incident light, the light source color characterization 540, light source angle characterization 535, background sheeting color 505 and foreground sheeting color 506 must be combined to determine how the background luminance value 500 and foreground luminance value 510 is converted to R_A (i.e., what percent of the incident photons of the foreground/background color were reflected back to the sensor).

The divergence pattern for the light source may have different profiles for various portions of the visible spectrum. In practice, a separate light source angle characterization profile may be required for each possible foreground and background color of any given object of interest 460.

A preferred high output light source 270 is of the type set forth in the attached installation and operation guide entitled "StrobeGuard™ High Intensity Obstruction Lighting System, Model No. SG-60," manufactured by Honeywell, Inc. In order to create a useful sign R_A profile 590 for an object of interest 460, intensity measurements 300 for frequent capture events 430 along a highway 150 while the capture vehicle 225 is in motion. For example, at vehicle speeds of 50 miles per hour, intensity measurements 300 should be taken at a rate of at least two per second.

The StrobeGuard™ SG-60 model has a recharge time of about 1.5 seconds between successive flash events. As a result, one SG-60 light will not provide enough flash events per second to allow an adequate number of intensity measurements 300. In order to meet the requirements of two flash events per second for a capture vehicle 225 traveling at 50 miles per hour, three of the StrobeGuard™ SG-60 units would need to be fired in a synchronized, round-robin pattern to obtain enough trigger events.

The light intensity measurement system 230 described herein attempts to remove observation angle 100 as an R_A variable. This is done by keeping the offset between the high output light source(s) 270 and light intensity sensor(s) 280 as low as possible. As mentioned previously, an R_A profile of a simulated roadway 580 can be computed, even though the intensity was not measured at every point and even though the capture vehicle 225 did not drive over every point. First, it is critical that the geometry of R_A is understood. Reflective materials like sign sheeting are designed to project near-columnated light back toward the light source. If a perfectly columnated light being reflected from the object of interest 460 being measured and a zero observation angle are assumed, the R_A values for all discrete locations along a ray projected from the object will be identical.

FIG. 9 shows how to compute R_A for any discrete location along a 4-lane divided highway 400. The R_A value for the desired point will be based on the R_A value that lies along the pathway traveled by the data acquisition vehicle 225. To compute this "reference R_A value" (the R_A value for a discrete location on or along a vehicle path), an undetermined retroreflectivity ray 570 is drawn from the desired location to the face of the reflective asset. The discrete location where the undetermined retroreflectivity ray 570 intersects the vehicle path will be used

as the reference R_A value. Since the discrete location on the vehicle path will always lie between two measured locations where intensity measurements 300 were made, the reference R_A value is computed by interpolating the two closest (in distance) R_A values along the vehicle path. As used herein, interpolate has the usual and typical meaning. It will be understood that interpolation consistent with the present invention can involve interpolation followed by extrapolation and shall also include such other special mathematical expressions used or created to account for border effects and effects at the lateral periphery and at the furthest distance where R_A may be reliably determined by application of the teaching of this disclosure.

If perfectly columnated light is assumed, the value of R_A at the desired point will be the same as the reference R_A value. In practice, all sign 190 sheeting materials will have some beam divergence for reflected light. This beam divergence information can be used to adjust the computed R_A value up (or down) from the reference R_A value for discrete locations closer to (or farther from) the object's face surface 130.

While knowing the normal vector 180 to a sign 190 face is not required, there are some advantages for planning and maintenance purposes that make the information useful. Several ways to compute the normal vector 180 for a sign 190 exist. First of all, the "assumption" method requires that the normal vector 180 from the surface of the sign 190 is assumed to be parallel to the capture vehicle pathway 410 at the nearest location of the capture vehicle pathway 410 to the sign 190. Second, a scanning laser operating in conjunction with an optical sensor and having a common field of view may be used to more precisely resolve the normal vector 180 from the object's face surface 130. Third, stereoscopic cameras 360 may be employed in a useful, albeit very imprecise manner of determining the normal vector 180. Fourth, the

assumption method and stereo imaging method may be combined whereby the normal vector 180 is assumed to lie parallel to the vehicle pathway 410 unless the stereo imaging output renders the assumption false.

Of the methods listed above, the highest precision measuring systems for determining the normal vector 180 consists of a scanned laser and associated optical sensor. This combination yields relative distance measurements between the capture vehicle 225 and the object's face surface 130 that are more precise than optical measurements with cameras. A laser scanner attached to the capture vehicle 225 and directed toward a roadside scene populated with retroreflective signs 130 generates a series of reflection points to the optical sensor that appear as a horizontal segment of points. The optical sensor must be fast enough (i.e., have adequate data acquisition rates) to capture at least several individual discrete measurements across the object's face surface 130 (or of any other reflective asset). In general, two types of laser scanners are suitable to be utilized according to the present invention; namely, single-axis scanners and dual-axis scanners. A preferred sensor is of the type set forth in the proposal entitled, "Holometrics 3-D Vision Technology," as referenced in the previously identified provisional patent application.

Since most all types of roadside signs 190 to be measured are disposed at various elevations relative to the highway 150 and the capture vehicle 225, a single-axis laser scanner cannot be mounted such that the scanning laser beam covers only a single elevation or constant height relative to the highway 150 and the capture vehicle 225. Rather, the inventors hereof suggest that use of a single-axis type laser scanner must either be mounted high on the capture vehicle 225 with a downward facing trajectory, or be mounted low on the capture vehicle 225 with an upward facing scanning trajectory. These two mounting schemes for a single-axis laser

scanner help ensure the lateral scan will intersect with virtually every object face surface 130 of all signs 190 or other objects of interest 460 present in a roadside scene regardless of the elevation or height or such signs relative to the roadway or to the moving platform.

Dual-axis laser scanners 335 circumvent the varying sign height problem inherently encountered if a single-axis laser scanner is employed as the source of integrated energy when practicing the teaching of the present invention. A dual-axis laser scanner 335 operates by continuously moving the scanning beam scan up and down at a relatively slow rate while sweeping the laser beam laterally from side to side across the field of view at a relatively more rapid rate.

In order to obtain the normal vector 180 for a sign 190 as taught hereunder, only a select horizontal series of discrete locations across the object's face surface 130 needs to be sensed by the high-speed optical sensor. For each point in the horizontal series of discrete locations recorded for a given sign 190 due to the incident radiation provided by the scanning laser, as sensed by the high speed optical sensor, the precise direction of the incident laser is recorded, thus allowing both distance and direction of the measured point to be determined.

Either of the scanning methods produces a massive number of sensed discrete locations representing discrete reflections of the incident laser radiation and each must be processed in order to correlate each of the sensed discrete locations with the object's face surface 130. Once the lateral series of discrete locations for a sign 190 is determined, simple triangulation methods are used to combine: (i) the vehicle location, (ii) vehicle heading vector, and (iii) scanned sign point to ultimately determine the normal vector 180 for the object's face surface 130.

As stated earlier, knowing the sign's 190 normal vector 180 can expand the utilization of

the present invention. The retroreflective properties of sign 190 sheeting materials are typically symmetrical about the vertical axis of the object's face surface 130. Because of this symmetry, R_A values (either computed or extrapolated/interpolated values) will be identical for rays that are symmetrical about the vertical axis.

FIG. 10 shows how the sign's 190 normal vector 180 can be used to extrapolate more R_A points. The R_A value for Point B is the same as the R_A value for Point A since their angle relative to the normal vector 180 is the same and since their distance from the sign 190 is the same. If Point B has the same relative angle (from the sign's 190 normal vector 180) as Point A, but lies closer to (or farther from) the object's face surface 130, the sign 190 material's beam divergence profile can be used to adjust the R_A value for Point B up (or down) from the value obtained for Point A.

The image capture system 250 and light intensity measurement system 230 are preferably free running, with measurements being made periodically during capture vehicle 225 operation. There is no requirement that these two systems be synchronized. In fact, these systems could operate in completely different capture vehicles 225, if necessary. When both systems are contained within the same capture vehicle 225, the only constraint for simultaneous operation is placed on the image capture system 250. Because of the intensity of the high output light source 270 in the light intensity measurement system 230, it is preferred that the image capture system 250 not capture frames at the same instant that the high output light source 270 is triggered. If images are actually captured while the high output light source 270 is triggered, their positional results would still be valid, but the colors displayed would be inaccurate because of the high output light being directed toward the (typically lower-thresholded) stereoscopic cameras 360.

One skilled in the art could completely eliminate any need for the image capture system 250 to know the firing events of the light intensity measurement system 230 by choosing sampling rates for the two systems that do not share any harmonic frequencies. On the rare occasions when the image capture system 250 captures images while the high output light source 270 is energized (or flashed), the skilled implementer could use time stamps to determine when this system simultaneity occurred and discard the imaging frames.

Referring now to FIGS. 14A and 14B, a preferred embodiment of the flowchart for the sign sheeting threshold algorithm will be described. In the preferred embodiment, certain assumptions are made that simplify the threshold algorithm process. It will be understood that additional assumptions could be made to further simplify the process, or that the process could be further expanded to allow certain of the assumptions to be avoided. In the preferred embodiment, it is assumed that each road sign 30 has only two colors of reflective sheeting and that the sheeting type is the same for both the background sheeting color 505 and the foreground sheeting color 506. It is also assumed that the retroreflectivity for both the background R_A 520 and the foreground R_A 530 are non-zero values. As previously described, the algorithm assumes that prefiltering has eliminated retroreflectivity values for road signs 30 that demonstrate some type of gross failure of the sheeting material, such as delamination, excessive surface wear, extreme color fade, vapor fade, graffiti, or excessive dirt or other obstructions that would prevent an accurate determination of the retroreflectivity value. Such filtering is preferably accomplished by image analysis of the color images using any number of known image analysis techniques for characterizing anomalies in images.

The sign sheeting threshold algorithm process is initiated at step 600. At steps 610 – 624,

the background sheeting color 505 is compared to a series of known sign sheeting colors. If the background color is yellow-green as determined at step 610, then the sign sheeting type is classified as Type VII as step 628. If the background color is white as determined at step 612, then the background R_A 520 is compared to the maximum retroreflectivity values for different sheeting types at steps 630, 632. If the background R_A 520 is less than the maximum white retroreflectivity value for sheeting Type I as determined at step 630, then the sign sheeting type is classified as Type I at step 634. Otherwise, if the background R_A 520 is less than the maximum white retroreflectivity value for sheeting Type III as determined at step 632, then the sign sheeting type is classified as Type III at step 636. If neither steps 630 or 632 are satisfied, then the sign sheeting type is classified as Type VII at step 638. A similar process is repeated for colors yellow at step 614 and steps 640, 642, orange at step 616 and steps 644, 646, red at step 618 and steps 650, 652.

If the background color is either green, blue or brown, as determined at steps 620, 622 and 624, then a second determination is made at step 660 whether the foreground color 506 is white and at step 670 whether the foreground color is yellow. If step 660 is satisfied, then the foreground R_A 520 is compared to the maximum retroreflectivity values for different sheeting types at steps 662, 664. If the foreground R_A 530 is less than the maximum white retroreflectivity value for sheeting Type I as determined at step 662, then the sign sheeting type is classified as Type I at step 666. Otherwise, if the foreground R_A 530 is less than the maximum white retroreflectivity value for sheeting Type III as determined at step 664, then the sign sheeting type is classified as Type III at step 668. If neither steps 662 or 664 are satisfied, then the sign sheeting type is classified as Type VII at step 669. A similar process is repeated for the

yellow foreground color at steps 672 and 674.

In the event that the background color 505 was not identified in steps 610-624 or the foreground color 506 was not identified in steps 660, 670, the sign sheeting type is considered undetermined at step 680. It will be understood that various options can be undertaken at step 680, including obtaining another color image and set of retroreflectivity values for the given road sign either with or without additional filtering or preprocessing of the raw data, marking the image and data for further review by an operator, discarding the information and marking the road sign as needing manual investigation, marking the road sign as needing replacement, or any combination of these or other operations.

Although the preferred embodiment of the threshold algorithm has been described with respect to the use of maximum retroreflectivity values, it will be understood that the threshold algorithm could utilize either minimum or maximum retroreflectivity values. Similarly, the combinations and orders of comparison of the colors and foreground or background colors may be altered and additional comparisons may be made to accommodate additional sheeting types that may be developed. Preferably, the colors 505 and 506 are determined based on CIELUV color values as evaluated by the image capture system 250. Alternatively, other equivalent color value systems such as RGB could be used for the color values. Preferably, the color values for the comparisons are a range of values specified by the manufacturer of the sheeting material. Alternatively, the color values for the comparison can be ranges of values empirically established.

ABSTRACT OF THE DISCLOSURE

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.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

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All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
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☐ **An Address is being provided for the correspondence Information of this application.**

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Application Information:

Title of the Invention	System and Assessment of Reflective Objects Along a Roadway		
Attorney Docket Number	2806.03US09	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
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Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
	Continuation of	14/512735	2014-10-13	

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/512735	Continuation of	14/025614	2013-09-12	8860944	2014-10-14

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/025614	Division of	13/205337	2011-08-08	8660311	2014-02-25

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13/205337	Division of	12/419843	2009-04-07	7995796	2011-08-09

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/419843	Continuation of	11/056926	2005-02-11	7515736	2009-04-07

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11/056926	Continuation of	09/928218	2001-08-10	6891960	2005-05-10

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
09/928218	Claims benefit of provisional	60/224761	2000-08-12

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
09/928218	Claims benefit of provisional	60/296596	2001-06-07

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Facet Technology Corp.		
Mailing Address Information For Applicant:			
Address 1	6517 City West Parkway		
Address 2			
City	Eden Prairie	**State/Province**	MN
Country	US	Postal Code	55344
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Brad Pedersen/			Date (YYYY-MM-DD)	2016-05-06
First Name	Brad	Last Name	Pedersen	Registration Number	32432

Additional Signature may be generated within this form by selecting the Add button. Add

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/148,722	05/06/2016	Jamie E. Retterath	2806.03US09

CONFIRMATION NO. 4034

FORMALITIES LETTER

OC000000083067160

24113
PATTERSON THUENTE PEDERSEN, P.A.
4800 IDS CENTER
80 SOUTH 8TH STREET
MINNEAPOLIS, MN 55402-2100

Date Mailed: 05/20/2016

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
- The application search fee must be submitted.
- The application examination fee must be submitted.

The application is informal since it does not comply with the regulations for the reason(s) indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125, is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). The specification, claims, and/or abstract page(s) submitted is not acceptable and cannot be scanned or properly stored because:
  - The application contains drawings, but the specification does not contain a brief description of the several views of the drawings as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9).

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

- Additional claim fees of $ **420** as an undiscounted entity, including any required multiple dependent claim fee, are required. Applicant must submit the additional claim fees or cancel the additional claims for which fees are due.

- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.
  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. No entity status discount is in effect. If applicant is qualified for small entity status, a written assertion of small entity status must be submitted to establish small entity status. (See 37 CFR 1.27). If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **280** basic filing fee.
- $ **140** surcharge.
- $ **600** search fee.
- $ **720** examination fee.
- $ **420** for **1** independent claims over 3.
- $(**0**) previous unapplied payment amount.
- $ **2160** TOTAL FEE BALANCE DUE.

Items Required To Avoid Processing Delays:

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Jamie E. Retterath
  Robert A. Laumeyer

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the
requirements it sets forth should be directed to the Office

of Data Management, Application Assistance Unit, at
(571) 272-4000 or **(571) 272-4200** or **1-888-786-0101**.

/cvorachack/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/148,722	05/06/2016	2872	0.00	2806.03US09	19	4

CONFIRMATION NO. 4034

FILING RECEIPT

24113
PATTERSON THUENTE PEDERSEN, P.A.
4800 IDS CENTER
80 SOUTH 8TH STREET
MINNEAPOLIS, MN 55402-2100

OC000000083067139

Date Mailed: 05/20/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Jamie E. Retterath, Excelsior, MN;
Robert A. Laumeyer, Eden Prairie, MN;

Applicant(s)

Facet Technology Corp., Eden Prairie, MN;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 14/512,735 10/13/2014 PAT 9335255
which is a CON of 14/025,614 09/12/2013 PAT 8860944
which is a DIV of 13/205,337 08/08/2011 PAT 8660311
which is a DIV of 12/419,843 04/07/2009 PAT 7995796
which is a CON of 11/056,926 02/11/2005 PAT 7515736
which is a CON of 09/928,218 08/10/2001 PAT 6891960
which claims benefit of 60/224,761 08/12/2000
and claims benefit of 60/296,596 06/07/2001

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 05/19/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/148,722**

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No

Title

System and Assessment of Reflective Objects Along a Roadway

Preliminary Class

359

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/148,722

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	19 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	4 minus 3 =	* 1				x 420 =	420
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2020

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
AMENDMENT A	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
AMENDMENT A	Application Size Fee (37 CFR 1.16(s))									
AMENDMENT A	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
AMENDMENT B	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
AMENDMENT B	Application Size Fee (37 CFR 1.16(s))									
AMENDMENT B	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	15/148,722
Filing Date	May 6, 2016
First Named Inventor	Retterath et al.
Title	SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY
Art Unit	2872
Examiner Name	unassigned
Attorney Docket Number	2806.03US09

SIGNATURE of Applicant or Patent Practitioner

Signature	/Brad Pedersen/	Date (Optional)	2016-09-16
Name	Brad Pedersen	Registration Number	32432
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 11/30/2014. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date
14/512,735	10/13/2014

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 24113

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Facet Technology Corp.

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	
Name	Jamie Retterath		
Title	President		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt	
EFS ID:	26948199
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	Jamie E. Retterath
Customer Number:	24113
Filer:	Bradley Pedersen/Michelle Arcand
Filer Authorized By:	Bradley Pedersen
Attorney Docket Number:	2806.03US09
Receipt Date:	16-SEP-2016
Filing Date:	06-MAY-2016
Time Stamp:	13:12:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1900
RAM confirmation Number	091616INTEFSW13133000
Deposit Account	1172
Authorized User	Bradley Pedersen
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	2806_03US09_RESMP.pdf	357304 802715cd09f7d1eeca0ed52be4c062324c6e5f97	no	2
Warnings:					
Information:					
2		2806_03US09_PREAMEND.pdf	2244198 852eac29f59a57d8bddb800b22d5fd80e603267e	yes	12

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
Specification	2	3
Claims	4	11
Applicant Arguments/Remarks Made in an Amendment	12	12

Warnings:					
Information:					
3	Specification	2806_03US09_SUBSPECMARKED.pdf	148136 ea702bd06b31216040b8090973f107f927068325	no	34
Warnings:					
Information:					
4	Specification	2806_03US09_SUBSPECCLEAN.pdf	147192 3a9e341bf38031352a2f63c479ced01d98ee8a7d	no	34
Warnings:					
Information:					

5	Transmittal Letter	2806_03US09_DECTRANSMITTAL.pdf	216148 fecec49c2f0cbb261ab18c3e1f2e68e5ee455985	no	1
Warnings:					
Information:					
6	Oath or Declaration filed	2806_03US09_DECRETTERATH.pdf	372956 6f0e09ff371528c751b5e3751f742d150ba6c568	no	1
Warnings:					
Information:					
7	Oath or Declaration filed	2806_03US09_DECLAUMEYER.pdf	363690 ac853b2c99158db033de11aecfc4eb29b2e49846	no	1
Warnings:					
Information:					
8	Power of Attorney	2806_03US09_POA.pdf	591383 1119911736c216ce42919ffe2ceec7cbfb795f98	no	2
Warnings:					
Information:					
9	Application Data Sheet	2806_03US09_SADS.pdf	125838 80bb628e3390daebf18e598243f72fd4ff1cfea8	no	9
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
10	Fee Worksheet (SB06)	fee-info.pdf	38597 a51e2cd9aec49d40c0ffa6f775addd2508a99bb0	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	4605442	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	~~Jamie~~ James	E.	Retterath	

Residence Information (Select One) ◉ US Residency ◯ Non US Residency ◯ Active US Military Service

City	Excelsior	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	c/o Facet Technology Corp.		
Address 2	6517 City West Parkway		
City	Eden Prairie	State/Province	MN
Postal Code	55344	Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Robert	A.	Laumeyer	

Residence Information (Select One) ◉ US Residency ◯ Non US Residency ◯ Active US Military Service

City	Eden Prairie	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	c/o Facet Technology Corp.		
Address 2	6517 City West Parkway		
City	Eden Prairie	State/Province	MN
Postal Code	55344	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

☐ **An Address is being provided for the correspondence Information of this application.**			
Customer Number	24113		
Email Address	pedersen@ptslaw.com	Add Email	Remove Email

Application Information:

Title of the Invention	System and Assessment of Reflective Objects Along a Roadway		
Attorney Docket Number	2806.03US09	**Small Entity Status Claimed** ☐	
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	24413		

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	14/512735	2014-10-13

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/512735	Continuation of	14/025614	2013-09-12	8860944	2014-10-14
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/025614	Division of	13/205337	2011-08-08	8660311	2014-02-25
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13/205337	Division of	12/419843	2009-04-07	7995796	2011-08-09
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/419843	Continuation of	11/056926	2005-02-11	7515736	2009-04-07
Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11/056926	Continuation of	09/928218	2001-08-10	6891960	2005-05-10

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
09/928218	Claims benefit of provisional	60/224761	2000-08-12
Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
09/928218	Claims benefit of provisional	60/296596	2001-06-07

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee ○ Legal Representative under 35 U.S.C. 117 ○ Joint Inventor

○ Person to whom the inventor is obligated to assign. ○ Person who shows sufficient proprietary interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	Facet Technology Corp.		
Mailing Address Information For Applicant:			
Address 1	6517 City West Parkway		
Address 2			
City	Eden Prairie	**State/Province**	MN
Country	US	Postal Code	55344
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Brad Pedersen/			Date (YYYY-MM-DD)	2016-09-16
First Name	Brad	Last Name	Pedersen	Registration Number	32432

Additional Signature may be generated within this form by selecting the Add button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2806.03US09
	Application Number	
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Electronic Patent Application Fee Transmittal

Application Number:	15148722
Filing Date:	06-May-2016
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	Jamie E. Retterath
Filer:	Bradley Pedersen/Michelle Arcand
Attorney Docket Number:	2806.03US09

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	280	280
Utility Search Fee	1111	1	600	600
Utility Examination Fee	1311	1	720	720
Pages:				
Claims:				
Claims in Excess of 20	1202	2	80	160
Miscellaneous-Filing:				
Late Filing Fee for Oath or Declaration	1051	1	140	140

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	System and Assessment of Reflective Objects Along a Roadway

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 14/512,735

filed on October 13, 2014

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: James E. Retterath Date (Optional): _____

Signature: James E Retterath

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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LEGAL NAME OF INVENTOR

Inventor: Robert A. Laumeyer Date (Optional): 11/14/2014

Signature: [illegible]

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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Attorney Docket No. 2806.03US09

ABSTRACT OF THE DISCLOSURE

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.

AMENDMENTS TO THE SPECIFICATION

In the Specification

Please substitute the following amended paragraph(s) and/or section(s) (deleted matter is shown by strikethrough and added matter is shown by underlining):

Page 1, line 4 - line 13:

The present application is a continuation of U.S. Application No. 14/512,735, filed October 13, 2014, now U.S. Patent No. 9,335,255, which is a continuation of U.S. Application No. 14/025,614, filed September 12, 2013, now U.S. Patent No. 8,860,944, which is a divisional of U.S. Application No. 13/205,337, filed August 8, 2011, now U.S. Patent No. 8,660,311, which is a divisional of U.S. Application No. 12/419,843, filed April 7, 2009, now U.S. Patent No. 7,995,796, which is a continuation of Application No. 11/056,926, filed February 11, 2005, now U.S. Patent No. 7,515,736, which is a continuation of Application No. 09/928,218, filed August 10, 2001, now U.S. Patent No. 6,891,960, which claims the benefit of the contents and filing date accorded to two U.S. Provisional Patent Applications, the first of which was filed on August 12, 2000 as Application No. 60/224,761, and the second of which was filed on June 7, 2001 as Application No. 60/296,596. The application is related to U.S. Patent No. 6,674,878, issued January 6, 2004, and U.S. Patent No. 6,453,056, issued September 17, 2002, which is a continuation of U.S. Patent No. 6,266,442, filed October 23, 1998, all of which are hereby incorporated by reference.

Page 9, line 13 - line 14:

FIGS. 14A, 14A-1, 14A-2 and 14B, 14B-1, 14B-2 depict a flowchart for a preferred embodiment of the threshold algorithm used to determine sign sheeting type.

Please substitute the attached Substitute Specification, marked "Clean Copy" for the Specification currently on file. A "Marked-Up Copy" showing all the changes made is also attached hereto (deleted matter is shown by strikethrough or double brackets and added matter is shown by underlining). This Substitute Specification includes no new matter.

SUBSTITUTE SPECIFICATION - MARKED COPY

Attorney Docket No. 2806.03US09

SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

RELATED APPLICATIONS

The present application is a continuation of U.S. Application No. 14/512,735, filed October 13, 2014, now U.S. Patent No. 9,335,255, which is a continuation of U.S. Application No. 14/025,614, filed September 12, 2013, now U.S. Patent No. 8,860,944, which is a divisional of U.S. Application No. 13/205,337, filed August 8, 2011, now U.S. Patent No. 8,660,311, which is a divisional of U.S. Application No. 12/419,843, filed April 7, 2009, now U.S. Patent No. 7,995,796, which is a continuation of Application No. 11/056,926, filed February 11, 2005, now U.S. Patent No. 7,515,736, which is a continuation of Application No. 09/928,218, filed August 10, 2001, now U.S. Patent No. 6,891,960, which claims the benefit of the contents and filing date accorded to two U.S. Provisional Patent Applications, the first of which was filed on August 12, 2000 as Application No. 60/224,761, and the second of which was filed on June 7, 2001 as Application No. 60/296,596. The application is related to U.S. Patent No. 6,674,878, issued January 6, 2004, and U.S. Patent No. 6,453,056, issued September 17, 2002, which is a continuation of U.S. Patent No. 6,266,442, filed October 23, 1998, all of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to the field of automated object recognition. More specifically, the present invention relates to a system for classifying different types of sheeting materials of road signs depicted in a videostream.

Attorney Docket No. 2806.03US09

BACKGROUND OF THE INVENTION

The goal of using an automated image identification system to recognize road signs and traffic signs is well known. Various techniques have been proposed for the recognition of road signs as part of a real-time automated vehicle navigation system. Due to the processing limitations imposed by a real-time environment, almost all of these techniques have involved template matching of shape and color. Given the wide variations in lighting and conditions, few if any of these systems provide accurate results.

Another use of automated road sign recognition is for the purpose of identifying and creating an accurate inventory of all road signs and traffic signs along a given street or highway. In one system as described in U.S. Patent No. 6,266,442, entitled, "METHOD AND APPARATUS FOR IDENTIFYING OBJECTS DEPICTED IN A VIDEOSTREAM," issued July 24, 2001 to Laumeyer et al., an acquisition vehicle equipped with video cameras and position identifying technology, such as global positioning satellite (GPS) receivers, is systematically driven over the roads and streets in a given area to produce a videostream tagged with location information. The tagged videostream is analyzed by computer software routines to perform object recognition of the desired objects, the road signs in this case. The results of this analysis are exported to an asset management database that stores attributes of the road signs.

Road signs are manufactured from a sheeting material made up of multiple layered films (one or more colored layers that are fused with a layer that produces the reflectivity) that is adhered to the sign face. There are different types of sheeting material utilized in the road sign industry. Currently, specific attributes about each road sign like retroreflectivity (measured in

candelas/lux/sq. meter) and sheeting type must be gathered manually by sending personnel in the field to measure retroreflectivity with a handheld device (like the Impulse RM retro-reflectometer from Laser Technology, Inc.) and to visually determine the sheeting type of each sign. Measurements of retroreflectivity and identification of sheeting type are helpful in evaluating the visibility of a sign and whether it has deteriorated due to a breakdown in the pigments or reflective material in the sheeting material of the sign. The retroreflectivity and sheeting type can also be used to produce a predictive model of how the sign will perform into the future based on the as-measured characteristics.

Generally, highway and street maintenance departments do not systematically evaluate the deterioration of the reflective materials used on road signs and markers. If inspections of road signs or markers are performed, they are typically accomplished by having inspectors manually position a handheld retroreflectometer directly on the surface of a sign in order to determine a retroreflectivity value for that sign. When there are a large number of road signs or markers (sometimes referred to as traffic control devices or TCDs) in a given jurisdiction, the task of manually inspecting all of these road signs and markers can be time consuming and expensive.

One technique for determining retroreflectivity, designated as "R_A" generally (and from time to time in this disclosure), which does not require that a retroreflectometer be placed directly on a sign is described in U.S. Patent No. 6,212,480 entitled, "APPARATUS AND METHOD FOR DETERMINING PRECISION REFLECTIVITY OF HIGHWAY SIGNS AND OTHER REFLECTIVE OBJECTS UTILIZING AN OPTICAL RANGE FINDER INSTRUMENT" issued April 3, 2001 to Dunne. The Dunne patent relates to a device

commercialized by the assignee thereof and marketed as the "Impulse RM" retro-reflectometer by Laser Technology, Inc., of Englewood, Colorado, USA. In use, handheld devices fabricated according to the Dunne patent are manually directed toward, or precisely at, a target object and then manually "fired." Once fired, the handheld device bounces a laser off the target object and measures the reflected laser energy that is then used to determine a retroreflectivity.

There are several drawbacks of the handheld laser arrangement described by the Dunne patent. The handheld device can only measure a single color at a time and can only measure one object at a time. The determination of retroreflectivity for a given object is valid only for the actual location, or discrete measurement point, along the roadway at which the measurement was made by the human operator. In order to validate a measurement made by such devices, the device must be taken back to the precise location in the field where an original measurement occurred for a valid comparison measurement to be made.

Another technique established for determining the retroreflectivity of signs has been introduced by the Federal Highway Administration (FHWA). The Sign Management and Retroreflectivity Tracking System (SMARTS) is a vehicle that contains one high intensity flash source (similar to the Honeywell StrobeGuard™ SG-60 device), one color camera, two black and white cameras, and a range-sensing device. The SMARTS vehicle requires two people for proper operation – one driver and one system operator to point the device at the target sign and arm the system. The SMARTS travels down the road, and the system operator "locks on" to a sign up ahead by rotating the camera and light assembly to point at the sign. At a distance of 60 meters, the system triggers the flash source to illuminate the sign surface, an image of which is captured by one of the black and white cameras. A histogram is produced of the sign's legend

and background that is then used to calculate retroreflectivity. A GPS system stores the location of the vehicle along with the calculated retroreflectivity in a computer database.

Like the handheld laser device of the Dunne patent, the SMARTS device can only determine retroreflectivity for one sign at a time and can only determine retroreflectivity for the discrete point on the roadway 60 meters from the sign. Two people are required to operate the vehicle and measurement system. The SMARTS vehicle cannot make retroreflectivity determinations for signs on both sides of the roadway in a single pass over the roadway, and does not produce nighttime sign visibility information for lanes on the roadway not traveled by the vehicle. Because the system operator in the SMARTS vehicle must locate and track signs to be measured while the vehicle is in motion, a high level of operational skill is required and the likelihood that a sign will be missed is significant. Most importantly for purposes of the present invention, the SMARTS device makes no attempt to automatically determine sheeting type of a sign.

There are an estimated 58 million individual TCDs that must be monitored and maintained in the United States and new TCD installations increase this number daily. For the reasons that have been described, the existing techniques for determining retroreflectivity do not lend themselves to increasing processing throughput so as to more easily manage the monitoring and maintenance of these TCDs. So called automated data collection systems often require that normal traffic be stopped during data collection because either the acquisition vehicle moved very slowly or because the acquisition vehicle had to come to a full stop before recording data about the roadside scene. Furthermore, a human operator is required to point one or more measurement devices at a sign of interest, perform data collection for that particular sign and

then set up the device for another particular sign of interest. With such a large number of TCDs that must be monitored, it would be desirable to provide an automated system for determining the retroreflectivity of road signs and markers that addresses these and other shortcomings of the existing techniques to enable a higher processing throughput of an automated determination of the retroreflectivity and sheeting classification of road signs and markers.

SUMMARY OF THE INVENTION

The present invention is a system for classifying different types of sheeting materials of road signs depicted in a videostream. 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.

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

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

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a capture vehicle used in a preferred embodiment of the present invention.

FIG. 2 is a data flow diagram of a preferred embodiment of the present invention.

FIG. 3 depicts a block diagram of the systems, subsystems and processes for capturing and processing roadside information from a moving platform in order to compute retroreflectivity according to the teaching of the present invention, wherein the arrows connecting the blocks of the diagram illustrate the connections between the systems and sub-

systems for computing R_A for each reflective asset recorded by the system of the present invention.

FIG. 4 depicts in diagram form, a preferred configuration of a sensor suite for use with a four-wheeled vehicle and the interconnections and couplings between the physical subcomponents of a system designed according to the present invention.

FIG. 5 is a plan view of a divided multi-lane vehicle pathway and depicts how periodic light intensity measurements may be made as a vehicle traverses the vehicle pathway over time and the discrete locations where such periodic light intensity measurements are performed by a data acquisition vehicle operating in accordance with the present invention.

FIG. 6 depicts four digital frames of data as captured by the intensity sensor at various discrete locations along the vehicle pathway depicted in FIG. 5.

FIG. 7 depicts a flowchart showing the steps required to convert intensity measurements into foreground and background retroreflectivity for a single reflective asset.

FIG. 8 depicts a typical light source intensity profile over the visible electromagnetic spectrum, which illustrates how different wavelengths of electromagnetic radiation possess different light intensities.

FIG. 9 depicts a preferred methodology for creating a retroreflectivity profile for all lanes and locations adjacent a vehicle pathway for a single reflective asset or sign which retroreflectivity profile is based upon a single pass of a data acquisition vehicle over the vehicle pathway.

FIG. 10 illustrates the facts that the normal vector of a reflective asset and the sheeting type of such a reflective asset create symmetry that may be used to determine retroreflectivity

values along all rays (or vectors) that have the same relative angle to the normal vector of the reflective asset.

FIG. 11 depicts the concept of observation angle (i.e., angle between incident light from a light source and an human observer (or light sensor), of the light as reflected from the face of a reflective asset) in the context of a conventional passenger vehicle traversing a vehicle pathway and where light from the vehicle reflects from a stop sign to the vehicle operator (shown in ghost).

FIG. 12 depicts the concept of entrance angle (i.e., angle between incident light from a light source mounted to a vehicle and a normal vector relative to the substantially flat face of a reflective surface disposed adjacent a vehicle pathway).

FIG. 13 is a graphic representation of the retroreflectivity performance for white sheeting for the three main types of sign sheeting.

FIGS. 14A, 14A-1, 14A-2 and 14B, 14B-1, 14B-2 depict a flowchart for a preferred embodiment of the threshold algorithm used to determine sign sheeting type.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, an acquisition vehicle 10 is equipped with multiple video cameras 12 that generate a series of raw videostreams 14 representative of a road or street over which the acquisition vehicle 10 is traveling. A global positioning satellite (GPS) receiver 16 supplies location information that is combined with the raw videostream 14 by a processor 18 to generate a tagged videostream 20.

In one embodiment as shown in FIG. 2, the tagged videostream 20 is analyzed by a

computer processor 22 to identify each road sign 30 and generate an asset management database 24 containing attribute and location information associated with each road sign 30. In an alternate embodiment, the identification of road signs 30 and generation of asset management database 24 is accomplished by the same processor 18 that tags the raw videostream 14. The details of this process are set out in U.S. Patent No. 6,453,056, issued September 17, 2002 to Laumeyer et al., which is hereby incorporated by reference.

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 be the reference values used in the threshold algorithm from which sign sheeting classification will be determined.

There are three main types of sheeting recognized in the industry: 1) Type I, commonly called Engineer Grade; 2) Type III, commonly called High Intensity; and 3) Type VII, commonly called Prismatic (Prismatic is sometimes divided into two groups – Type VIIa called Diamond Grade VIP, and Type VIIb called Diamond Grade LDP). In order to remove the

manual element of determining sheeting type and measuring retroreflectivity, the automated system of the present invention must accurately distinguish between these sheeting types. To accomplish this, the present invention utilizes the fact that all signs use the same sheeting type for foreground and background colors, that each road sign will have at least two colors and that the reflectivity for each color for each type of sheeting material has a relatively unique minimum initial retroreflectivity value. Most signs also have either White, Yellow or Orange colors as one of the colors on the sign. According to 3M, a manufacturer of reflective sheeting material, each color of the three sheeting types has a minimum initial retroreflectivity value. The following table lists the minimum values for common colors of each type:

Color	Type I Min.R_A	Type III Min.R_A	Type VIIa Min.R_A	Type VIIb Min.R_A
White	70	250	430	800
Yellow	50	170	350	660
Orange	25	100	200	360
Red	14.5	45	110	215
Green	9	45	45	80
Blue	4	20	20	43

This information is stored in a reflectivity/color database 50. The computer processor 22 accesses the database 50 using the maximum reflectivity value 44, 46 that corresponds to the color value 40, 42 for each color portion 34, 36 to determine the lowest possible sheeting type for each color. If the sheeting type is classified the same for all of the color portions 34, 36 for a

given road sign 30, then the sheeting class 52 is established as that type and this information is preferably stored in the asset management database 24 along with other attributes of the given road sign 30. If there is a discrepancy in the classification of sheeting material between different colors, a subsequent analysis by the processor 22 using, for example, a neural network program, to incorporate other determining factors, such as time of day, shadow, direction that could affect the retroreflectivity of the lighter colors (white, yellow and orange) more than the retroreflectivity of the darker colors (red, green, blue). In general, retroreflectivity values for lighter colors are weighted more heavily in resolving any discrepancies in classification of sheeting material.

The system described herein acquires many data points along the desired roadway without specifically targeting any objects of interest. For a roadside sign, the specific geometry of the sign (its orientation with respect to the roadway) is not necessarily known, nor is it required. The retroreflectivity points determined along the roadway are generated for the "as placed" road sign. Road signs will display their best retroreflectivity performance (have the highest retroreflectivity values) at or near the normal vector for the sign face. Since the geometry of the as-measured sign is not known, the system chooses the highest retroreflectivity value for that sign as the value that will be used in the threshold algorithm for sign sheeting classification.

There are several factors that can cause retroreflectivity readings for signs to actually be lower than the values for the underlying sheeting type. For example, a sign that has a layer of dirt on the face will produce lower retroreflectivity numbers than usual. If these lower numbers are used in the threshold comparison algorithm, an incorrect sheeting type may result. These

systematic errors can be removed by analyzing the retroreflectivity profile for the sign.

Sign sheeting types vary by the intensity of light that is reflected, but they also have reflective characteristics that give them unique signatures. Fig. 13 shows the profiles for Type I, Type III, and Type VII white sign sheeting types. Note the unique profiles for the three sheeting types. The preferred embodiment of the present invention, due to its ability to utilize multiple retroreflectivity points, can determine sheeting type by matching the as-measured profile with a uniformly reduced (where the entire curve is multiplied by a scaling factor that is less than one) characteristic curve that best correlates to the as-measured profile. This correlation step will establish the "best fit" performance curve based on the shape of the curve, without consideration for the magnitude of the curve. This "uniform reduction" of the sign sheeting performance curve allows the proper sheeting type to be determined, thus overcoming the problem with signs that have some type of surface anomaly. The performance curve correlation described above can be used in one of two ways – either as a validation of the proper determination of sheeting type from the threshold algorithm or as one of the qualification criteria prior to performing the threshold algorithm.

The sheeting types are all manufactured with multiple layers. In order for the present invention to accurately compute retroreflectivity for purposes of determining sheeting type of a given road sign, it is also necessary for the system to recognize gross sheeting failures like extreme color fade, de-lamination and vapor fade (darkening of the daylight appearance of the sheeting due to the corrosion of the metal sign backing). These gross failures will impact R_A measurements of the sheeting. Preferably, the sheeting determination system described herein tests for the absence of these gross failures prior to making any R_A measurements as part of the

process of categorizing sheeting type.

Retroreflectivity, designated as "R_A" generally (and from time to time in this disclosure), varies according to two key parameters, observation angle and entrance angle. Observation angle 100 (See FIG. 11) is the angular displacement between a light source 110 and a light sensor 120, as measured from an object face surface 130. In the case of a vehicle 140 driven by vehicle operator 145 moving along a highway 150, observation angle 100 is defined by the distance of the vehicle 140 from a sign face surface 130, the placement of the light source (headlights) 110 on the vehicle 140, and the position of the light sensor (eyes of the vehicle operator) 120 of the vehicle 140.

Entrance angle 160 (See FIG. 12) is defined as the angular displacement of the incident light 170 relative to the normal vector 180 from the object face surface 130. Entrance angles are impacted by the angular position 200 of a sign 190 relative to the highway 150, the sign 190 lateral distance 210 from the highway 150, and the distance 220 of the vehicle 140 from the sign 190. The inventors hereof are believed to be the first persons to successfully decrease the complexity and increase the efficiency of determination of R_A in the field.

The method of automated determination of R_A (See FIGS. 3 and 4) preferably utilizes a plurality of subsystems located on/in a capture vehicle 225. These subsystems include a light intensity measurement system 230, a vehicle positioning system 240, a color image capture system 250 and a data recording system 260. The light intensity measurement system 230 preferably includes a high output light source 270, a light intensity sensor 280 and an intensity measurement system control 290. A plurality of intensity measurements 300 are generated by the intensity measurement system 230 in response to the repeated strobing of the high output

light source 270. The vehicle positioning system 240 preferably includes a GPS receiver 310, an inertial navigation system 320, a distance measuring instrument 330 and a master clock 340. A position measurement 350 is generated by the vehicle positioning system 240. The color image capture system 250 preferably includes a stereoscopic camera pair 360, iris controls 370 and image capture control 380. The image capture system 250 generates a digital imagery stream 390.

The data required for the automated determination of R_A is accumulated while traversing a highway 150 with the capture vehicle 225 (See FIGS. 5 and 6). The capture vehicle 225 is shown on a 4-lane divided highway 400 with the capture vehicle 225 located in a proximate lane 410 to the stop sign 190. Preferably, a series of reflected light intensity frames 420 are generated at a constant measurement interval 430 as the capture vehicle travels along the highway 150.

Characterization of sign 190 R_A preferably utilizes the data recording system 260 to create a single tagged videostream 440 from the reflected light intensity frames 420, position measurements 350 and digital imagery 390 for each capture event 430 (See FIGS. 3, 5, 6, 7, and 8). A computer processor 450 identifies an object of interest 460 in a portion of the intensity frame 420 and determines the object of interest attributes 465 associated with that object of interest. Preferably, the objects of interest are identified from the digital imagery stream 390 generated by the color image capture system 250 in the manner as taught by U.S. Patent No. 6,266,442. Alternatively, other techniques known in the art for isolating an object of interest in a videostream can be used. 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.

For each object of interest 460, a background intensity measurement 470 and a foreground intensity measurement 480 is generated. Using an intensity algorithm 490, a light intensity sensor characterization 275 and a look-up-table 475, the computer processor 450 determines a background luminance value 500 and a foreground luminance value 510. Based on the background luminance value 500, the foreground luminance value 510, a characterization of light source wavelength 540, the background sheeting color 505 and the foreground sheeting color 506 the computer processor 450 characterizes a background R_A 520 and a foreground R_A 530 which are preferably reported separately for that object of interest.

The automated determination of multiple R_A values for a given object of interest 460 allows for the extrapolation of R_A values at an unmeasured viewing point 550 for an object of interest, such as a sign 190 (See FIGS. 9 and 10). In this example, the unmeasured viewing point resides in a nontraversed lane 560. The computer processor 450 defines an undetermined retroreflectivity ray 570 for unmeasured viewing point 550. Using interpolated values, the computer processor 450 determines an R_A value for unmeasured viewing point 550 and any point located along undetermined retroreflectivity ray 570.

Pursuant to the teaching of the present invention, a method and apparatus for determining retroreflectivity of relatively flat surface portions of objects disposed adjacent a highway 150 traversed by a vehicle 140 are taught, enabled, and depicted. The present invention may be utilized to detect and determine a retroreflective surface of interest disposed in a scene of non-retroreflective surfaces. That is, at least one object face surface 130 which exhibits retroreflectivity over at least a relatively narrow conical volume of magnitude of several degrees from a normal vector 180 originating from said object face surface 130.

In accordance with the present invention, a determination of the retroreflectivity of objects adjacent a highway 150 preferably includes providing: (i) position measurements 350 of a capture vehicle 225; (ii) precise position of the object of interest 460, or sign 190; (iii) intensity measurements 300 from a high output light source 270 and light intensity sensor 280 at measurement intervals 430 along said highway 150. Thus, a single-pass along the highway 150 by the capture vehicle 225 operating the light intensity measurement system 230, vehicle positioning system 240, image capture system 250 and data recording system 260 taught herein eliminates many shortcomings of the prior art and allows a single vehicle operator to conduct virtually continuous data measurement and acquisition of objects of interest 460 disposed adjacent a highway 150, at capture events 430 on said highway 150, without disrupting or interrupting other vehicle traffic traversing said highway 150.

FIG. 3 shows a block diagram of the on-board systems and the desktop systems required to record a tagged videostream 440 and create sign R_A profiles 590 for various signs 190 along a highway 150. The vehicle positioning system 240 contains all of the equipment to precisely locate the capture vehicle 225. All location information is synchronized with a master clock 340 preferably associated with a computer processor 450, which allows other data types to be merged with the vehicle location information at later stages in the post-processing. All of the on-board systems utilize the same master clock 340 information, thus allowing any events (image capture system 250, intensity measurement 300, and trigger controls 227, 228) to be correlated to the precise vehicle location and attitude during real-time, near real-time, or post-processing of the data acquired by the capture vehicle 225.

The image capture system 250 consists of at least one set of stereoscopic cameras 360

that gather digital imagery along the highway 150. Each capture event is combined with time stamp information from the vehicle positioning system 240 which also provides trigger control 227 for the image capture system 250 and trigger control 228 for the light intensity measurement system 230. These images and associated time stamps are later combined with photogrammetry to create objects of interest 460 and their associated attributes 465.

The light intensity measurement system 230 preferably consists of at least one high output light source(s) 270 and the associated light intensity sensor(s) 280. The precise control for these items is contained within the light intensity measurement system 230, and master time sequencing instrument 340 information received from the vehicle positioning system 240 (or computer processor 450) is combined to create a tagged videostream 440 so precise vehicle information can be utilized during post-processing.

The data recording system 260 is constantly monitoring control information from the other three on-board systems and records the necessary information. No post-processing is performed in the data recording system 260. As computer power increases in the future, one skilled in the art could produce a system whereby most, if not all, of the post-processing functions were performed in the capture vehicle 225, perhaps even in real time. The inventors can imagine several uses for the production of real-time information from the image capture system 250 in the future, but the cost of obtaining such information with today's computing power makes this option prohibitively expensive today.

The lower half of FIG. 3 shows the functional blocks for data post-processing. There are two main functions – the creation of objects of interest 460 and their associated attributes 465, and the determination of retroreflectivity for each object of interest 460. There are many

methods for creating objects of interest 460 from digital imagery, a few of which are discussed in this disclosure. The specific steps required to compute R_A are outlined in the discussion below.

Fig. 4 shows a typical configuration within a capture vehicle that is capable of producing data and imagery to create digital representations of objects of interest 460 and objects of interest retroreflectivity 466. The distance measuring instrument (DMI) 330, GPS receiver 310 and inertial navigation system (INS) 320 constitute the vehicle positioning system 240. Not all of these components are necessary to obtain the desired results, but better precision, and therefore more meaningful data, are produced if all three components are included.

The high output light source(s) 270 and light intensity sensor(s) 280 constitute the light intensity measurement system 230. These components make it possible to gather on-the-fly information for a desired highway 150 to allow the computation of object of interest retroreflectivity 466, as well as create a full 3-D sign R_A profile 590 for those same objects of interest 460.

The stereoscopic cameras 360 constitute the digital imagery system 390 that allows for the creation of objects of interest 460 and their associated attributes 465 during post-processing. More than one set of stereoscopic cameras 360 can be employed, thus increasing the accuracy of positional measurements for objects of interest 460. Other, non-stereoscopic imaging systems could also be employed with little or no change to the vehicle positioning system 240 or to the light intensity measurement system 230.

FIG. 5 shows the top view of a 4-lane divided highway 400 with a stop sign 190. The capture vehicle 225 is traveling in the proximate lane 410 to the stop sign 190 and makes intensity measurements 300 at capture events 430 while traveling the depicted route. The

techniques described herein will allow a retroreflectivity value for this stop sign 190 to be computed for any point along the 4-lane divided highway 400, independent of whether the intensity measurement 300 was made at that point and also independent of whether the capture vehicle 225 actually drove over that point.

It should be noted that intensity measurements 300 are made continuously while the capture vehicle 225 is in motion, thus requiring no prior knowledge of either the positions or the existence of signs.

FIG. 6 shows some typical reflected light intensity frames 420 as captured by the light intensity sensor 280 at various discrete locations along the roadway. These reflected light intensity frames 420 are the result of the high output light source 270 being energized (or flashed) while each reflected light intensity frame 420 is captured by one or more light intensity sensors 280. Since most of the objects in the scene are not reflective, and due to the high setting of the threshold range in the light intensity sensor(s) 280, the reflected light intensity frames 420 will actually show very few objects. For effective luminance results throughout a wide range of retroreflective materials, more than one light intensity sensor 280 may be required in order to get enough levels of gray within the active part of the visible spectrum. When multiple light intensity sensors 280 are required or used, they may each have different threshold ranges and each thus detect luminance values in different parts of the desired luminance ranges.

In order to compute retroreflectivity (R_A), one needs to know the luminance of the reflected energy. Luminance (expressed in candelas per square meter, or cd/m^2) will vary according to the intensity sensor characterization profile 275 of the light intensity sensor(s) 280 and the color of the material from which light is reflected.

Most roadway signs 190 contain text and/or symbols overlaid on a background. To ensure maximum visibility during day and night conditions, the colors of the foreground information (text and/or symbols) are chosen to have maximum day and night contrast with the background material. The techniques taught herein allow the retroreflectivity of roadway signs 190 to be determined for both foreground and background materials. Computing both the foreground 530 and background retroreflectivity 520 for each object of interest 460 allows us to ensure that the proper nighttime contrast is achieved for roadside assets. For example, a stop sign 190 with a red background and white lettering can provide good daytime contrast between the text and the sign background. But if these two materials display very similar retroreflectivity characteristics, their nighttime contrast will be minimal, thus rendering the sign ineffective during nighttime conditions.

FIG. 7 shows a block diagram of the steps required to transform intensity measurements 300 into foreground luminance values 510 and background luminance values 500. First, a black and white camera is preferably used as a light intensity sensor 280 to maximize the sensitivity of intensity measurements 300 (intensity will be determined from the gray value of the corresponding pixels). Think of an intensity measurement 300 as intensity values for N discrete points within the scene, where N corresponds to the number of pixels in the light intensity sensor's 280 array. For a light intensity sensor 280 that has a resolution of 640x480 pixels, there are 307,200 discrete intensity values for each intensity sensor measurement 300. Although the preferred embodiment utilizes an intensity sensor measurement 300 in the form of an array of discrete pixel intensity values, preferably a single pixel intensity value is selected and utilized for the automated determination of a corresponding retroreflectivity value. Alternatively, an average

or other combination of a group of pixel intensity values could be utilized for the automated determination of a corresponding retroreflectivity 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 intensity sensor characterization 275 is empirical information about the light intensity sensor 280 that is used to create the LUT 475. The same LUT 475 is used for computing foreground 510 and background luminance values 500.

The reader should note and appreciate that luminance is strictly a measure of the reflected light, while retroreflectivity (or R_A, expressed in candelas/lux/m^2) is a measure of the reflected light with respect to the incident light for that object. FIG. 7 shows the information needed to accurately convert luminance to R_A: sensor location, object location, light source characterization, and color of reflective material. For less precise R_A computations, a subset of the aforementioned characteristics can be utilized. For example, if a uniform light source (equal intensity throughout the scene), columnated light reflected from the surface of the object of

interest 460, and a known distance 220 between the object of interest 460 and the light intensity sensor 280 are all assumed, then the sheeting color and luminance value may be used to determine a rough approximation (within 20%, for example) for R_A.

To obtain the highest quality R_A calculations, all of the data shown in FIG. 7 should be utilized. The characterization of light source angle defines the amount of light emitted from the high output light source 270 throughout the source's field of view. Due to the limitations of lamp design and their associated reflectors, most semi-uniform light sources will have their greatest intensity at or near the normal vector for the light source. Since the high output light source(s) 270 are not aimed at objects of interest 460, the part of the incident light beam that is striking the object of interest 460 when the intensity measurement 300 is captured must be determined. Light source angle characterization is a process whereby empirical data from the light is modeled to establish the light intensity for numerous discrete vectors from the center of the light. When intensity values are determined for a discrete point in the scene (from the object's face surface 130), the light intensity sensor 280 location and heading, as well as the object of interest 460 location, are used to determine which light vector emanating from the light source was responsible for the resulting intensity measurement. The characterization of light source angle therefore, is a look-up-table where an object of interest's 460 angular displacement from the normal vector 180 for the high output light source 270 is converted to a light intensity for the associated vector.

Since the beam from the high output light source 270 is diverging, objects of interest 460 farther from the origin of the light will receive less incident radiation than those objects of interest 460 closer to the light. The characterization of light source angle is constructed at a few

discrete distances from the light. Simple geometry can be used to compute the incident radiation (using an interpolation method for an actual distance between two discrete distances in the characterization of light source angle) hitting the actual object of interest 460 based on the empirical data from the characterization of light source angle.

The preferred high output light source 270 is a uniform full-spectrum (visible spectrum) light. In practice, this light source will not emit the same intensity for all wavelengths of visible light. One variable of light source color characterization that should be considered is the output profile of the light throughout the visible spectrum. FIG. 8 shows a typical full-spectrum light source output profile. Note that the intensity in the blue area (400-500 nm) of the spectrum is stronger than in the red area (600-700 nm). This profile specifies the amount of light energy (number of photons) emitted for a given frequency. Since R_A depends on the intensity of the incident light, the light source color characterization 540, light source angle characterization 535, background sheeting color 505 and foreground sheeting color 506 must be combined to determine how the background luminance value 500 and foreground luminance value 510 is converted to R_A (i.e., what percent of the incident photons of the foreground/background color were reflected back to the sensor).

The divergence pattern for the light source may have different profiles for various portions of the visible spectrum. In practice, a separate light source angle characterization profile may be required for each possible foreground and background color of any given object of interest 460.

A preferred high output light source 270 is of the type set forth in the attached installation and operation guide entitled "StrobeGuard™ High Intensity Obstruction Lighting System, Model

No. SG-60," manufactured by Honeywell, Inc. In order to create a useful sign R_A profile 590 for an object of interest 460, intensity measurements 300 for frequent capture events 430 along a highway 150 while the capture vehicle 225 is in motion. For example, at vehicle speeds of 50 miles per hour, intensity measurements 300 should be taken at a rate of at least two per second. The StrobeGuard™ SG-60 model has a recharge time of about 1.5 seconds between successive flash events. As a result, one SG-60 light will not provide enough flash events per second to allow an adequate number of intensity measurements 300. In order to meet the requirements of two flash events per second for a capture vehicle 225 traveling at 50 miles per hour, three of the StrobeGuard™ SG-60 units would need to be fired in a synchronized, round-robin pattern to obtain enough trigger events.

The light intensity measurement system 230 described herein attempts to remove observation angle 100 as an R_A variable. This is done by keeping the offset between the high output light source(s) 270 and light intensity sensor(s) 280 as low as possible. As mentioned previously, an R_A profile of a simulated roadway 580 can be computed, even though the intensity was not measured at every point and even though the capture vehicle 225 did not drive over every point. First, it is critical that the geometry of R_A is understood. Reflective materials like sign sheeting are designed to project near-columnated light back toward the light source. If a perfectly columnated light being reflected from the object of interest 460 being measured and a zero observation angle are assumed, the R_A values for all discrete locations along a ray projected from the object will be identical.

FIG. 9 shows how to compute R_A for any discrete location along a 4-lane divided highway 400. The R_A value for the desired point will be based on the R_A value that lies along

the pathway traveled by the data acquisition vehicle 225. To compute this "reference R_A value" (the R_A value for a discrete location on or along a vehicle path), an undetermined retroreflectivity ray 570 is drawn from the desired location to the face of the reflective asset. The discrete location where the undetermined retroreflectivity ray 570 intersects the vehicle path will be used as the reference R_A value. Since the discrete location on the vehicle path will always lie between two measured locations where intensity measurements 300 were made, the reference R_A value is computed by interpolating the two closest (in distance) R_A values along the vehicle path. As used herein, interpolate has the usual and typical meaning. It will be understood that interpolation consistent with the present invention can involve interpolation followed by extrapolation and shall also include such other special mathematical expressions used or created to account for border effects and effects at the lateral periphery and at the furthest distance where R_A may be reliably determined by application of the teaching of this disclosure.

If perfectly columnated light is assumed, the value of R_A at the desired point will be the same as the reference R_A value. In practice, all sign 190 sheeting materials will have some beam divergence for reflected light. This beam divergence information can be used to adjust the computed R_A value up (or down) from the reference R_A value for discrete locations closer to (or farther from) the object's face surface 130.

While knowing the normal vector 180 to a sign 190 face is not required, there are some advantages for planning and maintenance purposes that make the information useful. Several ways to compute the normal vector 180 for a sign 190 exist. First of all, the "assumption" method requires that the normal vector 180 from the surface of the sign 190 is assumed to be parallel to the capture vehicle pathway 410 at the nearest location of the capture vehicle pathway

410 to the sign 190. Second, a scanning laser operating in conjunction with an optical sensor and having a common field of view may be used to more precisely resolve the normal vector 180 from the object's face surface 130. Third, stereoscopic cameras 360 may be employed in a useful, albeit very imprecise manner of determining the normal vector 180. Fourth, the assumption method and stereo imaging method may be combined whereby the normal vector 180 is assumed to lie parallel to the vehicle pathway 410 unless the stereo imaging output renders the assumption false.

Of the methods listed above, the highest precision measuring systems for determining the normal vector 180 consists of a scanned laser and associated optical sensor. This combination yields relative distance measurements between the capture vehicle 225 and the object's face surface 130 that are more precise than optical measurements with cameras. A laser scanner attached to the capture vehicle 225 and directed toward a roadside scene populated with retroreflective signs 130 generates a series of reflection points to the optical sensor that appear as a horizontal segment of points. The optical sensor must be fast enough (i.e., have adequate data acquisition rates) to capture at least several individual discrete measurements across the object's face surface 130 (or of any other reflective asset). In general, two types of laser scanners are suitable to be utilized according to the present invention; namely, single-axis scanners and dual-axis scanners. A preferred sensor is of the type set forth in the proposal entitled, "Holometrics 3-D Vision Technology," as referenced in the previously identified provisional patent application.

Since most all types of roadside signs 190 to be measured are disposed at various elevations relative to the highway 150 and the capture vehicle 225, a single-axis laser scanner cannot be mounted such that the scanning laser beam covers only a single elevation or constant

height relative to the highway 150 and the capture vehicle 225. Rather, the inventors hereof suggest that use of a single-axis type laser scanner must either be mounted high on the capture vehicle 225 with a downward facing trajectory, or be mounted low on the capture vehicle 225 with an upward facing scanning trajectory. These two mounting schemes for a single-axis laser scanner help ensure the lateral scan will intersect with virtually every object face surface 130 of all signs 190 or other objects of interest 460 present in a roadside scene regardless of the elevation or height or such signs relative to the roadway or to the moving platform.

Dual-axis laser scanners 335 circumvent the varying sign height problem inherently encountered if a single-axis laser scanner is employed as the source of integrated energy when practicing the teaching of the present invention. A dual-axis laser scanner 335 operates by continuously moving the scanning beam scan up and down at a relatively slow rate while sweeping the laser beam laterally from side to side across the field of view at a relatively more rapid rate.

In order to obtain the normal vector 180 for a sign 190 as taught hereunder, only a select horizontal series of discrete locations across the object's face surface 130 needs to be sensed by the high-speed optical sensor. For each point in the horizontal series of discrete locations recorded for a given sign 190 due to the incident radiation provided by the scanning laser, as sensed by the high speed optical sensor, the precise direction of the incident laser is recorded, thus allowing both distance and direction of the measured point to be determined.

Either of the scanning methods produces a massive number of sensed discrete locations representing discrete reflections of the incident laser radiation and each must be processed in order to correlate each of the sensed discrete locations with the object's face surface 130. Once

the lateral series of discrete locations for a sign 190 is determined, simple triangulation methods are used to combine: (i) the vehicle location, (ii) vehicle heading vector, and (iii) scanned sign point to ultimately determine the normal vector 180 for the object's face surface 130.

As stated earlier, knowing the sign's 190 normal vector 180 can expand the utilization of the present invention. The retroreflective properties of sign 190 sheeting materials are typically symmetrical about the vertical axis of the object's face surface 130. Because of this symmetry, R_A values (either computed or extrapolated/interpolated values) will be identical for rays that are symmetrical about the vertical axis.

FIG. 10 shows how the sign's 190 normal vector 180 can be used to extrapolate more R_A points. The R_A value for Point B is the same as the R_A value for Point A since their angle relative to the normal vector 180 is the same and since their distance from the sign 190 is the same. If Point B has the same relative angle (from the sign's 190 normal vector 180) as Point A, but lies closer to (or farther from) the object's face surface 130, the sign 190 material's beam divergence profile can be used to adjust the R_A value for Point B up (or down) from the value obtained for Point A.

The image capture system 250 and light intensity measurement system 230 are preferably free running, with measurements being made periodically during capture vehicle 225 operation. There is no requirement that these two systems be synchronized. In fact, these systems could operate in completely different capture vehicles 225, if necessary. When both systems are contained within the same capture vehicle 225, the only constraint for simultaneous operation is placed on the image capture system 250. Because of the intensity of the high output light source 270 in the light intensity measurement system 230, it is preferred that the image capture system

250 not capture frames at the same instant that the high output light source 270 is triggered. If images are actually captured while the high output light source 270 is triggered, their positional results would still be valid, but the colors displayed would be inaccurate because of the high output light being directed toward the (typically lower-thresholded) stereoscopic cameras 360.

One skilled in the art could completely eliminate any need for the image capture system 250 to know the firing events of the light intensity measurement system 230 by choosing sampling rates for the two systems that do not share any harmonic frequencies. On the rare occasions when the image capture system 250 captures images while the high output light source 270 is energized (or flashed), the skilled implementer could use time stamps to determine when this system simultaneity occurred and discard the imaging frames.

Referring now to FIGS. 14A and 14B, a preferred embodiment of the flowchart for the sign sheeting threshold algorithm will be described. In the preferred embodiment, certain assumptions are made that simplify the threshold algorithm process. It will be understood that additional assumptions could be made to further simplify the process, or that the process could be further expanded to allow certain of the assumptions to be avoided. In the preferred embodiment, it is assumed that each road sign 30 has only two colors of reflective sheeting and that the sheeting type is the same for both the background sheeting color 505 and the foreground sheeting color 506. It is also assumed that the retroreflectivity for both the background R_A 520 and the foreground R_A 530 are non-zero values. As previously described, the algorithm assumes that prefiltering has eliminated retroreflectivity values for road signs 30 that demonstrate some type of gross failure of the sheeting material, such as delamination, excessive surface wear, extreme color fade, vapor fade, graffiti, or excessive dirt or other obstructions that would prevent

an accurate determination of the retroreflectivity value. Such filtering is preferably accomplished by image analysis of the color images using any number of known image analysis techniques for characterizing anomalies in images.

The sign sheeting threshold algorithm process is initiated at step 600. At steps 610 – 624, the background sheeting color 505 is compared to a series of known sign sheeting colors. If the background color is yellow-green as determined at step 610, then the sign sheeting type is classified as Type VII as step 628. If the background color is white as determined at step 612, then the background R_A 520 is compared to the maximum retroreflectivity values for different sheeting types at steps 630, 632. If the background R_A 520 is less than the maximum white retroreflectivity value for sheeting Type I as determined at step 630, then the sign sheeting type is classified as Type I at step 634. Otherwise, if the background R_A 520 is less than the maximum white retroreflectivity value for sheeting Type III as determined at step 632, then the sign sheeting type is classified as Type III at step 636. If neither steps 630 or 632 are satisfied, then the sign sheeting type is classified as Type VII at step 638. A similar process is repeated for colors yellow at step 614 and steps 640, 642, orange at step 616 and steps 644, 646, red at step 618 and steps 650, 652.

If the background color is either green, blue or brown, as determined at steps 620, 622 and 624, then a second determination is made at step 660 whether the foreground color 506 is white and at step 670 whether the foreground color is yellow. If step 660 is satisfied, then the foreground R_A 520 is compared to the maximum retroreflectivity values for different sheeting types at steps 662, 664. If the foreground R_A 530 is less than the maximum white retroreflectivity value for sheeting Type I as determined at step 662, then the sign sheeting type

is classified as Type I at step 666. Otherwise, if the foreground R_A 530 is less than the maximum white retroreflectivity value for sheeting Type III as determined at step 664, then the sign sheeting type is classified as Type III at step 668. If neither steps 662 or 664 are satisfied, then the sign sheeting type is classified as Type VII at step 669. A similar process is repeated for the yellow foreground color at steps 672 and 674.

In the event that the background color 505 was not identified in steps 610-624 or the foreground color 506 was not identified in steps 660, 670, the sign sheeting type is considered undetermined at step 680. It will be understood that various options can be undertaken at step 680, including obtaining another color image and set of retroreflectivity values for the given road sign either with or without additional filtering or preprocessing of the raw data, marking the image and data for further review by an operator, discarding the information and marking the road sign as needing manual investigation, marking the road sign as needing replacement, or any combination of these or other operations.

Although the preferred embodiment of the threshold algorithm has been described with respect to the use of maximum retroreflectivity values, it will be understood that the threshold algorithm could utilize either minimum or maximum retroreflectivity values. Similarly, the combinations and orders of comparison of the colors and foreground or background colors may be altered and additional comparisons may be made to accommodate additional sheeting types that may be developed. Preferably, the colors 505 and 506 are determined based on CIELUV color values as evaluated by the image capture system 250. Alternatively, other equivalent color value systems such as RGB could be used for the color values. Preferably, the color values for the comparisons are a range of values specified by the manufacturer of the sheeting material.

Alternatively, the color values for the comparison can be ranges of values empirically established.

Attorney Docket No. 2806.03US09

ABSTRACT OF THE DISCLOSURE

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.

AMENDMENTS TO THE CLAIMS

A detailed listing of all claims that are, or were, in the present application, irrespective of whether the claim(s) remain(s) under examination in the application is presented below. The claims are presented in ascending order and each includes one status identifier. Those claims not cancelled or withdrawn but amended by the current amendment utilize the following notations for amendment: 1. deleted matter is shown by strikethrough for six or more characters and double brackets for five or fewer characters; and 2. added matter is shown by underlining.

1-19. (Cancelled).

Please add new claims 20 - 40 as follows:

20. (New) 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.

21. (New) The automated system of claim 20, wherein the road marker is an object of interest selected from the set consisting of a road sign or a pavement marker.

22. (New) The automated system of claim 20, wherein the computer processing system is configured to operate in a mode selected from post-processing or on-the-fly.

23. (New) The automated system of claim 20, wherein the light source is selected from the set consisting of a laser scanning device, a strobe light, or a vehicle headlight lamp.

24. (New) The automated system of claim 20, 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.

25. (New) The automated system of claim 24, 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.

26. (New) The automated system of claim 24, 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.

27. (New) The automated system of claim 20, 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.

28. (New) 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.

29. (New) The automated system of claim 28, wherein the road marker is selected from a set consisting of pavement markings and road signs.

30. (New) The automated system of claim 28, wherein the computer processing system is configured to operate in a mode selected from post-processing or on-the-fly.

31. (New) The automated system of claim 28, wherein the light source is selected from the set consisting of a laser scanning device, a strobe light, or a vehicle headlight lamp.

32. (New) The automated system of claim 28, 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.

33. (New) The automated system of claim 28, 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.

34. (New) The automated system of claim 28, 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.

35. (New) The automated system of claim 34, 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.

36. (New) An automated method for 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 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

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.

37. (New) The automated method of claim 36, 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.

38. (New) The automated method of claim 36, 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.

39. (New) The automated method of claim 36, wherein the computer processing system is further configured to determine an entrance angle and an observation angle of the road marker.

40. (New) The automated method of claim 36, 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.

41. (New) The automated method of claim 40, 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.

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 2806.03US09

Retterath et al. Confirmation No.: 4034

Application No.: 15/148,722 Examiner: *unassigned*

Filed: May 6, 2016 Group Art Unit: 2872

For: SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

TRANSMITTAL OF DECLARATION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

Enclosed is/are the Declaration(s). The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 16-0631.

The Commissioner is hereby authorized to charge any underpayment or credit any overpayment to Deposit Account No. 16-0631.

Respectfully submitted,

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Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 16-0631.

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PRELIMINARY AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

INTRODUCTORY COMMENTS

Prior to examination, please amend the above-identified application as follows:

The present amendment comprises the following sections:

A. Amendments to the Specification

B. Amendments to the Claims

C. Remarks

Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 16-0631.

REMARKS

Claims 1-19 are pending. By this Amendment, claims 1-19 are cancelled and new claims 20-41 are added. Support for the new claims can be found throughout the specification. No new matter has been added.

In view of the foregoing, it is submitted that this application is in condition for allowance. Favorable consideration and prompt allowance of the application are respectfully requested.

The Examiner is invited to telephone the undersigned if the Examiner believes it would be useful to advance prosecution.

Respectfully submitted,

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SUBSTITUTE SPECIFICATION - CLEAN COPY

Attorney Docket No. 2806.03US09

SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

RELATED APPLICATIONS

The present application is a continuation of U.S. Application No. 14/512,735, filed October 13, 2014, now U.S. Patent No. 9,335,255, which is a continuation of U.S. Application No. 14/025,614, filed September 12, 2013, now U.S. Patent No. 8,860,944, which is a divisional of U.S. Application No. 13/205,337, filed August 8, 2011, now U.S. Patent No. 8,660,311, which is a divisional of U.S. Application No. 12/419,843, filed April 7, 2009, now U.S. Patent No. 7,995,796, which is a continuation of Application No. 11/056,926, filed February 11, 2005, now U.S. Patent No. 7,515,736, which is a continuation of Application No. 09/928,218, filed August 10, 2001, now U.S. Patent No. 6,891,960, which claims the benefit of the contents and filing date accorded to two U.S. Provisional Patent Applications, the first of which was filed on August 12, 2000 as Application No. 60/224,761, and the second of which was filed on June 7, 2001 as Application No. 60/296,596. The application is related to U.S. Patent No. 6,674,878, issued January 6, 2004, and U.S. Patent No. 6,453,056, issued September 17, 2002, which is a continuation of U.S. Patent No. 6,266,442, filed October 23, 1998, all of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to the field of automated object recognition. More specifically, the present invention relates to a system for classifying different types of sheeting materials of road signs depicted in a videostream.

Attorney Docket No. 2806.03US09

BACKGROUND OF THE INVENTION

The goal of using an automated image identification system to recognize road signs and traffic signs is well known. Various techniques have been proposed for the recognition of road signs as part of a real-time automated vehicle navigation system. Due to the processing limitations imposed by a real-time environment, almost all of these techniques have involved template matching of shape and color. Given the wide variations in lighting and conditions, few if any of these systems provide accurate results.

Another use of automated road sign recognition is for the purpose of identifying and creating an accurate inventory of all road signs and traffic signs along a given street or highway. In one system as described in U.S. Patent No. 6,266,442, entitled, "METHOD AND APPARATUS FOR IDENTIFYING OBJECTS DEPICTED IN A VIDEOSTREAM," issued July 24, 2001 to Laumeyer et al., an acquisition vehicle equipped with video cameras and position identifying technology, such as global positioning satellite (GPS) receivers, is systematically driven over the roads and streets in a given area to produce a videostream tagged with location information. The tagged videostream is analyzed by computer software routines to perform object recognition of the desired objects, the road signs in this case. The results of this analysis are exported to an asset management database that stores attributes of the road signs.

Road signs are manufactured from a sheeting material made up of multiple layered films (one or more colored layers that are fused with a layer that produces the reflectivity) that is adhered to the sign face. There are different types of sheeting material utilized in the road sign industry. Currently, specific attributes about each road sign like retroreflectivity (measured in

candelas/lux/sq. meter) and sheeting type must be gathered manually by sending personnel in the field to measure retroreflectivity with a handheld device (like the Impulse RM retro-reflectometer from Laser Technology, Inc.) and to visually determine the sheeting type of each sign. Measurements of retroreflectivity and identification of sheeting type are helpful in evaluating the visibility of a sign and whether it has deteriorated due to a breakdown in the pigments or reflective material in the sheeting material of the sign. The retroreflectivity and sheeting type can also be used to produce a predictive model of how the sign will perform into the future based on the as-measured characteristics.

Generally, highway and street maintenance departments do not systematically evaluate the deterioration of the reflective materials used on road signs and markers. If inspections of road signs or markers are performed, they are typically accomplished by having inspectors manually position a handheld retroreflectometer directly on the surface of a sign in order to determine a retroreflectivity value for that sign. When there are a large number of road signs or markers (sometimes referred to as traffic control devices or TCDs) in a given jurisdiction, the task of manually inspecting all of these road signs and markers can be time consuming and expensive.

One technique for determining retroreflectivity, designated as "R_A" generally (and from time to time in this disclosure), which does not require that a retroreflectometer be placed directly on a sign is described in U.S. Patent No. 6,212,480 entitled, "APPARATUS AND METHOD FOR DETERMINING PRECISION REFLECTIVITY OF HIGHWAY SIGNS AND OTHER REFLECTIVE OBJECTS UTILIZING AN OPTICAL RANGE FINDER INSTRUMENT" issued April 3, 2001 to Dunne. The Dunne patent relates to a device

commercialized by the assignee thereof and marketed as the "Impulse RM" retro-reflectometer by Laser Technology, Inc., of Englewood, Colorado, USA. In use, handheld devices fabricated according to the Dunne patent are manually directed toward, or precisely at, a target object and then manually "fired." Once fired, the handheld device bounces a laser off the target object and measures the reflected laser energy that is then used to determine a retroreflectivity.

There are several drawbacks of the handheld laser arrangement described by the Dunne patent. The handheld device can only measure a single color at a time and can only measure one object at a time. The determination of retroreflectivity for a given object is valid only for the actual location, or discrete measurement point, along the roadway at which the measurement was made by the human operator. In order to validate a measurement made by such devices, the device must be taken back to the precise location in the field where an original measurement occurred for a valid comparison measurement to be made.

Another technique established for determining the retroreflectivity of signs has been introduced by the Federal Highway Administration (FHWA). The Sign Management and Retroreflectivity Tracking System (SMARTS) is a vehicle that contains one high intensity flash source (similar to the Honeywell StrobeGuard™ SG-60 device), one color camera, two black and white cameras, and a range-sensing device. The SMARTS vehicle requires two people for proper operation – one driver and one system operator to point the device at the target sign and arm the system. The SMARTS travels down the road, and the system operator "locks on" to a sign up ahead by rotating the camera and light assembly to point at the sign. At a distance of 60 meters, the system triggers the flash source to illuminate the sign surface, an image of which is captured by one of the black and white cameras. A histogram is produced of the sign's legend

and background that is then used to calculate retroreflectivity. A GPS system stores the location of the vehicle along with the calculated retroreflectivity in a computer database.

Like the handheld laser device of the Dunne patent, the SMARTS device can only determine retroreflectivity for one sign at a time and can only determine retroreflectivity for the discrete point on the roadway 60 meters from the sign. Two people are required to operate the vehicle and measurement system. The SMARTS vehicle cannot make retroreflectivity determinations for signs on both sides of the roadway in a single pass over the roadway, and does not produce nighttime sign visibility information for lanes on the roadway not traveled by the vehicle. Because the system operator in the SMARTS vehicle must locate and track signs to be measured while the vehicle is in motion, a high level of operational skill is required and the likelihood that a sign will be missed is significant. Most importantly for purposes of the present invention, the SMARTS device makes no attempt to automatically determine sheeting type of a sign.

There are an estimated 58 million individual TCDs that must be monitored and maintained in the United States and new TCD installations increase this number daily. For the reasons that have been described, the existing techniques for determining retroreflectivity do not lend themselves to increasing processing throughput so as to more easily manage the monitoring and maintenance of these TCDs. So called automated data collection systems often require that normal traffic be stopped during data collection because either the acquisition vehicle moved very slowly or because the acquisition vehicle had to come to a full stop before recording data about the roadside scene. Furthermore, a human operator is required to point one or more measurement devices at a sign of interest, perform data collection for that particular sign and

then set up the device for another particular sign of interest. With such a large number of TCDs that must be monitored, it would be desirable to provide an automated system for determining the retroreflectivity of road signs and markers that addresses these and other shortcomings of the existing techniques to enable a higher processing throughput of an automated determination of the retroreflectivity and sheeting classification of road signs and markers.

SUMMARY OF THE INVENTION

The present invention is a system for classifying different types of sheeting materials of road signs depicted in a videostream. 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.

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

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

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a capture vehicle used in a preferred embodiment of the present invention.

FIG. 2 is a data flow diagram of a preferred embodiment of the present invention.

FIG. 3 depicts a block diagram of the systems, subsystems and processes for capturing and processing roadside information from a moving platform in order to compute retroreflectivity according to the teaching of the present invention, wherein the arrows connecting the blocks of the diagram illustrate the connections between the systems and sub-

systems for computing R_A for each reflective asset recorded by the system of the present invention.

FIG. 4 depicts in diagram form, a preferred configuration of a sensor suite for use with a four-wheeled vehicle and the interconnections and couplings between the physical subcomponents of a system designed according to the present invention.

FIG. 5 is a plan view of a divided multi-lane vehicle pathway and depicts how periodic light intensity measurements may be made as a vehicle traverses the vehicle pathway over time and the discrete locations where such periodic light intensity measurements are performed by a data acquisition vehicle operating in accordance with the present invention.

FIG. 6 depicts four digital frames of data as captured by the intensity sensor at various discrete locations along the vehicle pathway depicted in FIG. 5.

FIG. 7 depicts a flowchart showing the steps required to convert intensity measurements into foreground and background retroreflectivity for a single reflective asset.

FIG. 8 depicts a typical light source intensity profile over the visible electromagnetic spectrum, which illustrates how different wavelengths of electromagnetic radiation possess different light intensities.

FIG. 9 depicts a preferred methodology for creating a retroreflectivity profile for all lanes and locations adjacent a vehicle pathway for a single reflective asset or sign which retroreflectivity profile is based upon a single pass of a data acquisition vehicle over the vehicle pathway.

FIG. 10 illustrates the facts that the normal vector of a reflective asset and the sheeting type of such a reflective asset create symmetry that may be used to determine retroreflectivity

values along all rays (or vectors) that have the same relative angle to the normal vector of the reflective asset.

FIG. 11 depicts the concept of observation angle (i.e., angle between incident light from a light source and an human observer (or light sensor), of the light as reflected from the face of a reflective asset) in the context of a conventional passenger vehicle traversing a vehicle pathway and where light from the vehicle reflects from a stop sign to the vehicle operator (shown in ghost).

FIG. 12 depicts the concept of entrance angle (i.e., angle between incident light from a light source mounted to a vehicle and a normal vector relative to the substantially flat face of a reflective surface disposed adjacent a vehicle pathway).

FIG. 13 is a graphic representation of the retroreflectivity performance for white sheeting for the three main types of sign sheeting.

FIGS. 14A, 14A-1, 14A-2 and 14B, 14B-1, 14B-2 depict a flowchart for a preferred embodiment of the threshold algorithm used to determine sign sheeting type.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, an acquisition vehicle 10 is equipped with multiple video cameras 12 that generate a series of raw videostreams 14 representative of a road or street over which the acquisition vehicle 10 is traveling. A global positioning satellite (GPS) receiver 16 supplies location information that is combined with the raw videostream 14 by a processor 18 to generate a tagged videostream 20.

In one embodiment as shown in FIG. 2, the tagged videostream 20 is analyzed by a

computer processor 22 to identify each road sign 30 and generate an asset management database 24 containing attribute and location information associated with each road sign 30. In an alternate embodiment, the identification of road signs 30 and generation of asset management database 24 is accomplished by the same processor 18 that tags the raw videostream 14. The details of this process are set out in U.S. Patent No. 6,453,056, issued September 17, 2002 to Laumeyer et al., which is hereby incorporated by reference.

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 be the reference values used in the threshold algorithm from which sign sheeting classification will be determined.

There are three main types of sheeting recognized in the industry: 1) Type I, commonly called Engineer Grade; 2) Type III, commonly called High Intensity; and 3) Type VII, commonly called Prismatic (Prismatic is sometimes divided into two groups – Type VIIa called Diamond Grade VIP, and Type VIIb called Diamond Grade LDP). In order to remove the

manual element of determining sheeting type and measuring retroreflectivity, the automated system of the present invention must accurately distinguish between these sheeting types. To accomplish this, the present invention utilizes the fact that all signs use the same sheeting type for foreground and background colors, that each road sign will have at least two colors and that the reflectivity for each color for each type of sheeting material has a relatively unique minimum initial retroreflectivity value. Most signs also have either White, Yellow or Orange colors as one of the colors on the sign. According to 3M, a manufacturer of reflective sheeting material, each color of the three sheeting types has a minimum initial retroreflectivity value. The following table lists the minimum values for common colors of each type:

Color	Type I Min.R_A	Type III Min.R_A	Type VIIa Min.R_A	Type VIIb Min.R_A
White	70	250	430	800
Yellow	50	170	350	660
Orange	25	100	200	360
Red	14.5	45	110	215
Green	9	45	45	80
Blue	4	20	20	43

This information is stored in a reflectivity/color database 50. The computer processor 22 accesses the database 50 using the maximum reflectivity value 44, 46 that corresponds to the color value 40, 42 for each color portion 34, 36 to determine the lowest possible sheeting type for each color. If the sheeting type is classified the same for all of the color portions 34, 36 for a

given road sign 30, then the sheeting class 52 is established as that type and this information is preferably stored in the asset management database 24 along with other attributes of the given road sign 30. If there is a discrepancy in the classification of sheeting material between different colors, a subsequent analysis by the processor 22 using, for example, a neural network program, to incorporate other determining factors, such as time of day, shadow, direction that could affect the retroreflectivity of the lighter colors (white, yellow and orange) more than the retroreflectivity of the darker colors (red, green, blue). In general, retroreflectivity values for lighter colors are weighted more heavily in resolving any discrepancies in classification of sheeting material.

The system described herein acquires many data points along the desired roadway without specifically targeting any objects of interest. For a roadside sign, the specific geometry of the sign (its orientation with respect to the roadway) is not necessarily known, nor is it required. The retroreflectivity points determined along the roadway are generated for the "as placed" road sign. Road signs will display their best retroreflectivity performance (have the highest retroreflectivity values) at or near the normal vector for the sign face. Since the geometry of the as-measured sign is not known, the system chooses the highest retroreflectivity value for that sign as the value that will be used in the threshold algorithm for sign sheeting classification.

There are several factors that can cause retroreflectivity readings for signs to actually be lower than the values for the underlying sheeting type. For example, a sign that has a layer of dirt on the face will produce lower retroreflectivity numbers than usual. If these lower numbers are used in the threshold comparison algorithm, an incorrect sheeting type may result. These

systematic errors can be removed by analyzing the retroreflectivity profile for the sign.

Sign sheeting types vary by the intensity of light that is reflected, but they also have reflective characteristics that give them unique signatures. Fig. 13 shows the profiles for Type I, Type III, and Type VII white sign sheeting types. Note the unique profiles for the three sheeting types. The preferred embodiment of the present invention, due to its ability to utilize multiple retroreflectivity points, can determine sheeting type by matching the as-measured profile with a uniformly reduced (where the entire curve is multiplied by a scaling factor that is less than one) characteristic curve that best correlates to the as-measured profile. This correlation step will establish the "best fit" performance curve based on the shape of the curve, without consideration for the magnitude of the curve. This "uniform reduction" of the sign sheeting performance curve allows the proper sheeting type to be determined, thus overcoming the problem with signs that have some type of surface anomaly. The performance curve correlation described above can be used in one of two ways – either as a validation of the proper determination of sheeting type from the threshold algorithm or as one of the qualification criteria prior to performing the threshold algorithm.

The sheeting types are all manufactured with multiple layers. In order for the present invention to accurately compute retroreflectivity for purposes of determining sheeting type of a given road sign, it is also necessary for the system to recognize gross sheeting failures like extreme color fade, de-lamination and vapor fade (darkening of the daylight appearance of the sheeting due to the corrosion of the metal sign backing). These gross failures will impact R_A measurements of the sheeting. Preferably, the sheeting determination system described herein tests for the absence of these gross failures prior to making any R_A measurements as part of the

process of categorizing sheeting type.

Retroreflectivity, designated as "R_A" generally (and from time to time in this disclosure), varies according to two key parameters, observation angle and entrance angle. Observation angle 100 (See FIG. 11) is the angular displacement between a light source 110 and a light sensor 120, as measured from an object face surface 130. In the case of a vehicle 140 driven by vehicle operator 145 moving along a highway 150, observation angle 100 is defined by the distance of the vehicle 140 from a sign face surface 130, the placement of the light source (headlights) 110 on the vehicle 140, and the position of the light sensor (eyes of the vehicle operator) 120 of the vehicle 140.

Entrance angle 160 (See FIG. 12) is defined as the angular displacement of the incident light 170 relative to the normal vector 180 from the object face surface 130. Entrance angles are impacted by the angular position 200 of a sign 190 relative to the highway 150, the sign 190 lateral distance 210 from the highway 150, and the distance 220 of the vehicle 140 from the sign 190. The inventors hereof are believed to be the first persons to successfully decrease the complexity and increase the efficiency of determination of R_A in the field.

The method of automated determination of R_A (See FIGS. 3 and 4) preferably utilizes a plurality of subsystems located on/in a capture vehicle 225. These subsystems include a light intensity measurement system 230, a vehicle positioning system 240, a color image capture system 250 and a data recording system 260. The light intensity measurement system 230 preferably includes a high output light source 270, a light intensity sensor 280 and an intensity measurement system control 290. A plurality of intensity measurements 300 are generated by the intensity measurement system 230 in response to the repeated strobing of the high output

light source 270. The vehicle positioning system 240 preferably includes a GPS receiver 310, an inertial navigation system 320, a distance measuring instrument 330 and a master clock 340. A position measurement 350 is generated by the vehicle positioning system 240. The color image capture system 250 preferably includes a stereoscopic camera pair 360, iris controls 370 and image capture control 380. The image capture system 250 generates a digital imagery stream 390.

The data required for the automated determination of R_A is accumulated while traversing a highway 150 with the capture vehicle 225 (See FIGS. 5 and 6). The capture vehicle 225 is shown on a 4-lane divided highway 400 with the capture vehicle 225 located in a proximate lane 410 to the stop sign 190. Preferably, a series of reflected light intensity frames 420 are generated at a constant measurement interval 430 as the capture vehicle travels along the highway 150.

Characterization of sign 190 R_A preferably utilizes the data recording system 260 to create a single tagged videostream 440 from the reflected light intensity frames 420, position measurements 350 and digital imagery 390 for each capture event 430 (See FIGS. 3, 5, 6, 7, and 8). A computer processor 450 identifies an object of interest 460 in a portion of the intensity frame 420 and determines the object of interest attributes 465 associated with that object of interest. Preferably, the objects of interest are identified from the digital imagery stream 390 generated by the color image capture system 250 in the manner as taught by U.S. Patent No. 6,266,442. Alternatively, other techniques known in the art for isolating an object of interest in a videostream can be used. 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.

For each object of interest 460, a background intensity measurement 470 and a foreground intensity measurement 480 is generated. Using an intensity algorithm 490, a light intensity sensor characterization 275 and a look-up-table 475, the computer processor 450 determines a background luminance value 500 and a foreground luminance value 510. Based on the background luminance value 500, the foreground luminance value 510, a characterization of light source wavelength 540, the background sheeting color 505 and the foreground sheeting color 506 the computer processor 450 characterizes a background R_A 520 and a foreground R_A 530 which are preferably reported separately for that object of interest.

The automated determination of multiple R_A values for a given object of interest 460 allows for the extrapolation of R_A values at an unmeasured viewing point 550 for an object of interest, such as a sign 190 (See FIGS. 9 and 10). In this example, the unmeasured viewing point resides in a nontraversed lane 560. The computer processor 450 defines an undetermined retroreflectivity ray 570 for unmeasured viewing point 550. Using interpolated values, the computer processor 450 determines an R_A value for unmeasured viewing point 550 and any point located along undetermined retroreflectivity ray 570.

Pursuant to the teaching of the present invention, a method and apparatus for determining retroreflectivity of relatively flat surface portions of objects disposed adjacent a highway 150 traversed by a vehicle 140 are taught, enabled, and depicted. The present invention may be utilized to detect and determine a retroreflective surface of interest disposed in a scene of non-retroreflective surfaces. That is, at least one object face surface 130 which exhibits retroreflectivity over at least a relatively narrow conical volume of magnitude of several degrees from a normal vector 180 originating from said object face surface 130.

In accordance with the present invention, a determination of the retroreflectivity of objects adjacent a highway 150 preferably includes providing: (i) position measurements 350 of a capture vehicle 225; (ii) precise position of the object of interest 460, or sign 190; (iii) intensity measurements 300 from a high output light source 270 and light intensity sensor 280 at measurement intervals 430 along said highway 150. Thus, a single-pass along the highway 150 by the capture vehicle 225 operating the light intensity measurement system 230, vehicle positioning system 240, image capture system 250 and data recording system 260 taught herein eliminates many shortcomings of the prior art and allows a single vehicle operator to conduct virtually continuous data measurement and acquisition of objects of interest 460 disposed adjacent a highway 150, at capture events 430 on said highway 150, without disrupting or interrupting other vehicle traffic traversing said highway 150.

FIG. 3 shows a block diagram of the on-board systems and the desktop systems required to record a tagged videostream 440 and create sign R_A profiles 590 for various signs 190 along a highway 150. The vehicle positioning system 240 contains all of the equipment to precisely locate the capture vehicle 225. All location information is synchronized with a master clock 340 preferably associated with a computer processor 450, which allows other data types to be merged with the vehicle location information at later stages in the post-processing. All of the on-board systems utilize the same master clock 340 information, thus allowing any events (image capture system 250, intensity measurement 300, and trigger controls 227, 228) to be correlated to the precise vehicle location and attitude during real-time, near real-time, or post-processing of the data acquired by the capture vehicle 225.

The image capture system 250 consists of at least one set of stereoscopic cameras 360

that gather digital imagery along the highway 150. Each capture event is combined with time stamp information from the vehicle positioning system 240 which also provides trigger control 227 for the image capture system 250 and trigger control 228 for the light intensity measurement system 230. These images and associated time stamps are later combined with photogrammetry to create objects of interest 460 and their associated attributes 465.

The light intensity measurement system 230 preferably consists of at least one high output light source(s) 270 and the associated light intensity sensor(s) 280. The precise control for these items is contained within the light intensity measurement system 230, and master time sequencing instrument 340 information received from the vehicle positioning system 240 (or computer processor 450) is combined to create a tagged videostream 440 so precise vehicle information can be utilized during post-processing.

The data recording system 260 is constantly monitoring control information from the other three on-board systems and records the necessary information. No post-processing is performed in the data recording system 260. As computer power increases in the future, one skilled in the art could produce a system whereby most, if not all, of the post-processing functions were performed in the capture vehicle 225, perhaps even in real time. The inventors can imagine several uses for the production of real-time information from the image capture system 250 in the future, but the cost of obtaining such information with today's computing power makes this option prohibitively expensive today.

The lower half of FIG. 3 shows the functional blocks for data post-processing. There are two main functions – the creation of objects of interest 460 and their associated attributes 465, and the determination of retroreflectivity for each object of interest 460. There are many

methods for creating objects of interest 460 from digital imagery, a few of which are discussed in this disclosure. The specific steps required to compute R_A are outlined in the discussion below.

Fig. 4 shows a typical configuration within a capture vehicle that is capable of producing data and imagery to create digital representations of objects of interest 460 and objects of interest retroreflectivity 466. The distance measuring instrument (DMI) 330, GPS receiver 310 and inertial navigation system (INS) 320 constitute the vehicle positioning system 240. Not all of these components are necessary to obtain the desired results, but better precision, and therefore more meaningful data, are produced if all three components are included.

The high output light source(s) 270 and light intensity sensor(s) 280 constitute the light intensity measurement system 230. These components make it possible to gather on-the-fly information for a desired highway 150 to allow the computation of object of interest retroreflectivity 466, as well as create a full 3-D sign R_A profile 590 for those same objects of interest 460.

The stereoscopic cameras 360 constitute the digital imagery system 390 that allows for the creation of objects of interest 460 and their associated attributes 465 during post-processing. More than one set of stereoscopic cameras 360 can be employed, thus increasing the accuracy of positional measurements for objects of interest 460. Other, non-stereoscopic imaging systems could also be employed with little or no change to the vehicle positioning system 240 or to the light intensity measurement system 230.

FIG. 5 shows the top view of a 4-lane divided highway 400 with a stop sign 190. The capture vehicle 225 is traveling in the proximate lane 410 to the stop sign 190 and makes intensity measurements 300 at capture events 430 while traveling the depicted route. The

techniques described herein will allow a retroreflectivity value for this stop sign 190 to be computed for any point along the 4-lane divided highway 400, independent of whether the intensity measurement 300 was made at that point and also independent of whether the capture vehicle 225 actually drove over that point.

It should be noted that intensity measurements 300 are made continuously while the capture vehicle 225 is in motion, thus requiring no prior knowledge of either the positions or the existence of signs.

FIG. 6 shows some typical reflected light intensity frames 420 as captured by the light intensity sensor 280 at various discrete locations along the roadway. These reflected light intensity frames 420 are the result of the high output light source 270 being energized (or flashed) while each reflected light intensity frame 420 is captured by one or more light intensity sensors 280. Since most of the objects in the scene are not reflective, and due to the high setting of the threshold range in the light intensity sensor(s) 280, the reflected light intensity frames 420 will actually show very few objects. For effective luminance results throughout a wide range of retroreflective materials, more than one light intensity sensor 280 may be required in order to get enough levels of gray within the active part of the visible spectrum. When multiple light intensity sensors 280 are required or used, they may each have different threshold ranges and each thus detect luminance values in different parts of the desired luminance ranges.

In order to compute retroreflectivity (R_A), one needs to know the luminance of the reflected energy. Luminance (expressed in candelas per square meter, or cd/m^2) will vary according to the intensity sensor characterization profile 275 of the light intensity sensor(s) 280 and the color of the material from which light is reflected.

Most roadway signs 190 contain text and/or symbols overlaid on a background. To ensure maximum visibility during day and night conditions, the colors of the foreground information (text and/or symbols) are chosen to have maximum day and night contrast with the background material. The techniques taught herein allow the retroreflectivity of roadway signs 190 to be determined for both foreground and background materials. Computing both the foreground 530 and background retroreflectivity 520 for each object of interest 460 allows us to ensure that the proper nighttime contrast is achieved for roadside assets. For example, a stop sign 190 with a red background and white lettering can provide good daytime contrast between the text and the sign background. But if these two materials display very similar retroreflectivity characteristics, their nighttime contrast will be minimal, thus rendering the sign ineffective during nighttime conditions.

FIG. 7 shows a block diagram of the steps required to transform intensity measurements 300 into foreground luminance values 510 and background luminance values 500. First, a black and white camera is preferably used as a light intensity sensor 280 to maximize the sensitivity of intensity measurements 300 (intensity will be determined from the gray value of the corresponding pixels). Think of an intensity measurement 300 as intensity values for N discrete points within the scene, where N corresponds to the number of pixels in the light intensity sensor's 280 array. For a light intensity sensor 280 that has a resolution of 640x480 pixels, there are 307,200 discrete intensity values for each intensity sensor measurement 300. Although the preferred embodiment utilizes an intensity sensor measurement 300 in the form of an array of discrete pixel intensity values, preferably a single pixel intensity value is selected and utilized for the automated determination of a corresponding retroreflectivity value. Alternatively, an average

or other combination of a group of pixel intensity values could be utilized for the automated determination of a corresponding retroreflectivity 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 intensity sensor characterization 275 is empirical information about the light intensity sensor 280 that is used to create the LUT 475. The same LUT 475 is used for computing foreground 510 and background luminance values 500.

The reader should note and appreciate that luminance is strictly a measure of the reflected light, while retroreflectivity (or R_A, expressed in candelas/lux/m^2) is a measure of the reflected light with respect to the incident light for that object. FIG. 7 shows the information needed to accurately convert luminance to R_A: sensor location, object location, light source characterization, and color of reflective material. For less precise R_A computations, a subset of the aforementioned characteristics can be utilized. For example, if a uniform light source (equal intensity throughout the scene), columnated light reflected from the surface of the object of

interest 460, and a known distance 220 between the object of interest 460 and the light intensity sensor 280 are all assumed, then the sheeting color and luminance value may be used to determine a rough approximation (within 20%, for example) for R_A.

To obtain the highest quality R_A calculations, all of the data shown in FIG. 7 should be utilized. The characterization of light source angle defines the amount of light emitted from the high output light source 270 throughout the source's field of view. Due to the limitations of lamp design and their associated reflectors, most semi-uniform light sources will have their greatest intensity at or near the normal vector for the light source. Since the high output light source(s) 270 are not aimed at objects of interest 460, the part of the incident light beam that is striking the object of interest 460 when the intensity measurement 300 is captured must be determined. Light source angle characterization is a process whereby empirical data from the light is modeled to establish the light intensity for numerous discrete vectors from the center of the light. When intensity values are determined for a discrete point in the scene (from the object's face surface 130), the light intensity sensor 280 location and heading, as well as the object of interest 460 location, are used to determine which light vector emanating from the light source was responsible for the resulting intensity measurement. The characterization of light source angle therefore, is a look-up-table where an object of interest's 460 angular displacement from the normal vector 180 for the high output light source 270 is converted to a light intensity for the associated vector.

Since the beam from the high output light source 270 is diverging, objects of interest 460 farther from the origin of the light will receive less incident radiation than those objects of interest 460 closer to the light. The characterization of light source angle is constructed at a few

discrete distances from the light. Simple geometry can be used to compute the incident radiation (using an interpolation method for an actual distance between two discrete distances in the characterization of light source angle) hitting the actual object of interest 460 based on the empirical data from the characterization of light source angle.

The preferred high output light source 270 is a uniform full-spectrum (visible spectrum) light. In practice, this light source will not emit the same intensity for all wavelengths of visible light. One variable of light source color characterization that should be considered is the output profile of the light throughout the visible spectrum. FIG. 8 shows a typical full-spectrum light source output profile. Note that the intensity in the blue area (400-500 nm) of the spectrum is stronger than in the red area (600-700 nm). This profile specifies the amount of light energy (number of photons) emitted for a given frequency. Since R_A depends on the intensity of the incident light, the light source color characterization 540, light source angle characterization 535, background sheeting color 505 and foreground sheeting color 506 must be combined to determine how the background luminance value 500 and foreground luminance value 510 is converted to R_A (i.e., what percent of the incident photons of the foreground/background color were reflected back to the sensor).

The divergence pattern for the light source may have different profiles for various portions of the visible spectrum. In practice, a separate light source angle characterization profile may be required for each possible foreground and background color of any given object of interest 460.

A preferred high output light source 270 is of the type set forth in the attached installation and operation guide entitled "StrobeGuard™ High Intensity Obstruction Lighting System, Model

No. SG-60," manufactured by Honeywell, Inc. In order to create a useful sign R_A profile 590 for an object of interest 460, intensity measurements 300 for frequent capture events 430 along a highway 150 while the capture vehicle 225 is in motion. For example, at vehicle speeds of 50 miles per hour, intensity measurements 300 should be taken at a rate of at least two per second. The StrobeGuard™ SG-60 model has a recharge time of about 1.5 seconds between successive flash events. As a result, one SG-60 light will not provide enough flash events per second to allow an adequate number of intensity measurements 300. In order to meet the requirements of two flash events per second for a capture vehicle 225 traveling at 50 miles per hour, three of the StrobeGuard™ SG-60 units would need to be fired in a synchronized, round-robin pattern to obtain enough trigger events.

The light intensity measurement system 230 described herein attempts to remove observation angle 100 as an R_A variable. This is done by keeping the offset between the high output light source(s) 270 and light intensity sensor(s) 280 as low as possible. As mentioned previously, an R_A profile of a simulated roadway 580 can be computed, even though the intensity was not measured at every point and even though the capture vehicle 225 did not drive over every point. First, it is critical that the geometry of R_A is understood. Reflective materials like sign sheeting are designed to project near-columnated light back toward the light source. If a perfectly columnated light being reflected from the object of interest 460 being measured and a zero observation angle are assumed, the R_A values for all discrete locations along a ray projected from the object will be identical.

FIG. 9 shows how to compute R_A for any discrete location along a 4-lane divided highway 400. The R_A value for the desired point will be based on the R_A value that lies along

the pathway traveled by the data acquisition vehicle 225. To compute this "reference R_A value" (the R_A value for a discrete location on or along a vehicle path), an undetermined retroreflectivity ray 570 is drawn from the desired location to the face of the reflective asset. The discrete location where the undetermined retroreflectivity ray 570 intersects the vehicle path will be used as the reference R_A value. Since the discrete location on the vehicle path will always lie between two measured locations where intensity measurements 300 were made, the reference R_A value is computed by interpolating the two closest (in distance) R_A values along the vehicle path. As used herein, interpolate has the usual and typical meaning. It will be understood that interpolation consistent with the present invention can involve interpolation followed by extrapolation and shall also include such other special mathematical expressions used or created to account for border effects and effects at the lateral periphery and at the furthest distance where R_A may be reliably determined by application of the teaching of this disclosure.

If perfectly columnated light is assumed, the value of R_A at the desired point will be the same as the reference R_A value. In practice, all sign 190 sheeting materials will have some beam divergence for reflected light. This beam divergence information can be used to adjust the computed R_A value up (or down) from the reference R_A value for discrete locations closer to (or farther from) the object's face surface 130.

While knowing the normal vector 180 to a sign 190 face is not required, there are some advantages for planning and maintenance purposes that make the information useful. Several ways to compute the normal vector 180 for a sign 190 exist. First of all, the "assumption" method requires that the normal vector 180 from the surface of the sign 190 is assumed to be parallel to the capture vehicle pathway 410 at the nearest location of the capture vehicle pathway

410 to the sign 190. Second, a scanning laser operating in conjunction with an optical sensor and having a common field of view may be used to more precisely resolve the normal vector 180 from the object's face surface 130. Third, stereoscopic cameras 360 may be employed in a useful, albeit very imprecise manner of determining the normal vector 180. Fourth, the assumption method and stereo imaging method may be combined whereby the normal vector 180 is assumed to lie parallel to the vehicle pathway 410 unless the stereo imaging output renders the assumption false.

Of the methods listed above, the highest precision measuring systems for determining the normal vector 180 consists of a scanned laser and associated optical sensor. This combination yields relative distance measurements between the capture vehicle 225 and the object's face surface 130 that are more precise than optical measurements with cameras. A laser scanner attached to the capture vehicle 225 and directed toward a roadside scene populated with retroreflective signs 130 generates a series of reflection points to the optical sensor that appear as a horizontal segment of points. The optical sensor must be fast enough (i.e., have adequate data acquisition rates) to capture at least several individual discrete measurements across the object's face surface 130 (or of any other reflective asset). In general, two types of laser scanners are suitable to be utilized according to the present invention; namely, single-axis scanners and dual-axis scanners. A preferred sensor is of the type set forth in the proposal entitled, "Holometrics 3-D Vision Technology," as referenced in the previously identified provisional patent application.

Since most all types of roadside signs 190 to be measured are disposed at various elevations relative to the highway 150 and the capture vehicle 225, a single-axis laser scanner cannot be mounted such that the scanning laser beam covers only a single elevation or constant

height relative to the highway 150 and the capture vehicle 225. Rather, the inventors hereof suggest that use of a single-axis type laser scanner must either be mounted high on the capture vehicle 225 with a downward facing trajectory, or be mounted low on the capture vehicle 225 with an upward facing scanning trajectory. These two mounting schemes for a single-axis laser scanner help ensure the lateral scan will intersect with virtually every object face surface 130 of all signs 190 or other objects of interest 460 present in a roadside scene regardless of the elevation or height or such signs relative to the roadway or to the moving platform.

Dual-axis laser scanners 335 circumvent the varying sign height problem inherently encountered if a single-axis laser scanner is employed as the source of integrated energy when practicing the teaching of the present invention. A dual-axis laser scanner 335 operates by continuously moving the scanning beam scan up and down at a relatively slow rate while sweeping the laser beam laterally from side to side across the field of view at a relatively more rapid rate.

In order to obtain the normal vector 180 for a sign 190 as taught hereunder, only a select horizontal series of discrete locations across the object's face surface 130 needs to be sensed by the high-speed optical sensor. For each point in the horizontal series of discrete locations recorded for a given sign 190 due to the incident radiation provided by the scanning laser, as sensed by the high speed optical sensor, the precise direction of the incident laser is recorded, thus allowing both distance and direction of the measured point to be determined.

Either of the scanning methods produces a massive number of sensed discrete locations representing discrete reflections of the incident laser radiation and each must be processed in order to correlate each of the sensed discrete locations with the object's face surface 130. Once

the lateral series of discrete locations for a sign 190 is determined, simple triangulation methods are used to combine: (i) the vehicle location, (ii) vehicle heading vector, and (iii) scanned sign point to ultimately determine the normal vector 180 for the object's face surface 130.

As stated earlier, knowing the sign's 190 normal vector 180 can expand the utilization of the present invention. The retroreflective properties of sign 190 sheeting materials are typically symmetrical about the vertical axis of the object's face surface 130. Because of this symmetry, R_A values (either computed or extrapolated/interpolated values) will be identical for rays that are symmetrical about the vertical axis.

FIG. 10 shows how the sign's 190 normal vector 180 can be used to extrapolate more R_A points. The R_A value for Point B is the same as the R_A value for Point A since their angle relative to the normal vector 180 is the same and since their distance from the sign 190 is the same. If Point B has the same relative angle (from the sign's 190 normal vector 180) as Point A, but lies closer to (or farther from) the object's face surface 130, the sign 190 material's beam divergence profile can be used to adjust the R_A value for Point B up (or down) from the value obtained for Point A.

The image capture system 250 and light intensity measurement system 230 are preferably free running, with measurements being made periodically during capture vehicle 225 operation. There is no requirement that these two systems be synchronized. In fact, these systems could operate in completely different capture vehicles 225, if necessary. When both systems are contained within the same capture vehicle 225, the only constraint for simultaneous operation is placed on the image capture system 250. Because of the intensity of the high output light source 270 in the light intensity measurement system 230, it is preferred that the image capture system

250 not capture frames at the same instant that the high output light source 270 is triggered. If images are actually captured while the high output light source 270 is triggered, their positional results would still be valid, but the colors displayed would be inaccurate because of the high output light being directed toward the (typically lower-thresholded) stereoscopic cameras 360.

One skilled in the art could completely eliminate any need for the image capture system 250 to know the firing events of the light intensity measurement system 230 by choosing sampling rates for the two systems that do not share any harmonic frequencies. On the rare occasions when the image capture system 250 captures images while the high output light source 270 is energized (or flashed), the skilled implementer could use time stamps to determine when this system simultaneity occurred and discard the imaging frames.

Referring now to FIGS. 14A and 14B, a preferred embodiment of the flowchart for the sign sheeting threshold algorithm will be described. In the preferred embodiment, certain assumptions are made that simplify the threshold algorithm process. It will be understood that additional assumptions could be made to further simplify the process, or that the process could be further expanded to allow certain of the assumptions to be avoided. In the preferred embodiment, it is assumed that each road sign 30 has only two colors of reflective sheeting and that the sheeting type is the same for both the background sheeting color 505 and the foreground sheeting color 506. It is also assumed that the retroreflectivity for both the background R_A 520 and the foreground R_A 530 are non-zero values. As previously described, the algorithm assumes that prefiltering has eliminated retroreflectivity values for road signs 30 that demonstrate some type of gross failure of the sheeting material, such as delamination, excessive surface wear, extreme color fade, vapor fade, graffiti, or excessive dirt or other obstructions that would prevent

an accurate determination of the retroreflectivity value. Such filtering is preferably accomplished by image analysis of the color images using any number of known image analysis techniques for characterizing anomalies in images.

The sign sheeting threshold algorithm process is initiated at step 600. At steps 610 – 624, the background sheeting color 505 is compared to a series of known sign sheeting colors. If the background color is yellow-green as determined at step 610, then the sign sheeting type is classified as Type VII as step 628. If the background color is white as determined at step 612, then the background R_A 520 is compared to the maximum retroreflectivity values for different sheeting types at steps 630, 632. If the background R_A 520 is less than the maximum white retroreflectivity value for sheeting Type I as determined at step 630, then the sign sheeting type is classified as Type I at step 634. Otherwise, if the background R_A 520 is less than the maximum white retroreflectivity value for sheeting Type III as determined at step 632, then the sign sheeting type is classified as Type III at step 636. If neither steps 630 or 632 are satisfied, then the sign sheeting type is classified as Type VII at step 638. A similar process is repeated for colors yellow at step 614 and steps 640, 642, orange at step 616 and steps 644, 646, red at step 618 and steps 650, 652.

If the background color is either green, blue or brown, as determined at steps 620, 622 and 624, then a second determination is made at step 660 whether the foreground color 506 is white and at step 670 whether the foreground color is yellow. If step 660 is satisfied, then the foreground R_A 520 is compared to the maximum retroreflectivity values for different sheeting types at steps 662, 664. If the foreground R_A 530 is less than the maximum white retroreflectivity value for sheeting Type I as determined at step 662, then the sign sheeting type

is classified as Type I at step 666. Otherwise, if the foreground R_A 530 is less than the maximum white retroreflectivity value for sheeting Type III as determined at step 664, then the sign sheeting type is classified as Type III at step 668. If neither steps 662 or 664 are satisfied, then the sign sheeting type is classified as Type VII at step 669. A similar process is repeated for the yellow foreground color at steps 672 and 674.

In the event that the background color 505 was not identified in steps 610-624 or the foreground color 506 was not identified in steps 660, 670, the sign sheeting type is considered undetermined at step 680. It will be understood that various options can be undertaken at step 680, including obtaining another color image and set of retroreflectivity values for the given road sign either with or without additional filtering or preprocessing of the raw data, marking the image and data for further review by an operator, discarding the information and marking the road sign as needing manual investigation, marking the road sign as needing replacement, or any combination of these or other operations.

Although the preferred embodiment of the threshold algorithm has been described with respect to the use of maximum retroreflectivity values, it will be understood that the threshold algorithm could utilize either minimum or maximum retroreflectivity values. Similarly, the combinations and orders of comparison of the colors and foreground or background colors may be altered and additional comparisons may be made to accommodate additional sheeting types that may be developed. Preferably, the colors 505 and 506 are determined based on CIELUV color values as evaluated by the image capture system 250. Alternatively, other equivalent color value systems such as RGB could be used for the color values. Preferably, the color values for the comparisons are a range of values specified by the manufacturer of the sheeting material.

Alternatively, the color values for the comparison can be ranges of values empirically established.

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 2806.03US09

Retterath et al. Confirmation No.: 4034

Application No.: 15/148,722 Examiner: *unassigned*

Filed: May 6, 2016 Group Art Unit: 2872

For: SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

RESPONSE TO NOTICE TO FILE MISSING PARTS
OF NONPROVISIONAL APPLICATION

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

In response to the Notice to File Missing Parts of Application - Filing Date Granted mailed May 20, 2016, electronic payment is submitted by credit card for the surcharge and filing fee. Submitted herewith is/are the Declaration(s). Submitted herewith is a Preliminary Amendment. The Substitute Specification includes no new matter.

The Commissioner is hereby authorized to grant any extensions of time and to charge any fees under 37 C.F.R. §§ 1.16 and 1.17 that may be required during the entire pendency of this application to Deposit Account No. 16-0631.

Entry of these documents should complete all of the filing formalities and fully satisfy all requirements of the Notice to File Missing Parts. Accordingly, examination and allowance of this application in due course are respectfully solicited.

The Commissioner is hereby authorized to charge any underpayment or credit any overpayment to Deposit Account No. 16-0631.

Respectfully submitted,

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Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 16-0631.

Electronic Acknowledgement Receipt	
EFS ID:	26948199
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	Jamie E. Retterath
Customer Number:	24113
Filer:	Bradley Pedersen/Michelle Arcand
Filer Authorized By:	Bradley Pedersen
Attorney Docket Number:	2806.03US09
Receipt Date:	16-SEP-2016
Filing Date:	06-MAY-2016
Time Stamp:	13:12:43
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1900
RAM confirmation Number	091616INTEFSW13133000
Deposit Account	160631
Authorized User	Bradley Pedersen

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	2806_03US09_RESMP.pdf	357304 802715cd09f7d1eeca0ed52be4c062324c6e5f97	no	2
Warnings:					
Information:					
2		2806_03US09_PREAMEND.pdf	2244198 852eac29f59a57d8bddb800b22d5fd80e603267e	yes	12
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Preliminary Amendment		1	1	
	Specification		2	3	
	Claims		4	11	
	Applicant Arguments/Remarks Made in an Amendment		12	12	
Warnings:					
Information:					
3	Specification	2806_03US09_SUBSPECMARKED.pdf	148136 ea702bd06b31216040b8090973f107f927068325	no	34
Warnings:					
Information:					
4	Specification	2806_03US09_SUBSPECCLEAN.pdf	147192 3a9e341bf38031352a2f63c479ced01d98ee8a7d	no	34
Warnings:					
Information:					

5	Transmittal Letter	2806_03US09_DECTRANSMITTAL.pdf	216148 fecec49c2f0cbb261ab18c3e1f2e68e5ee455985	no	1
Warnings:					
Information:					
6	Oath or Declaration filed	2806_03US09_DECRETTERATH.pdf	372956 6f0e09ff371528c751b5e3751f742d150ba6c568	no	1
Warnings:					
Information:					
7	Oath or Declaration filed	2806_03US09_DECLAUMEYER.pdf	363690 ac853b2c99158db033de11aecfc4eb29b2e49846	no	1
Warnings:					
Information:					
8	Power of Attorney	2806_03US09_POA.pdf	591383 1119911736c216ce42919ffe2ceec7cbfb795f98	no	2
Warnings:					
Information:					
9	Application Data Sheet	2806_03US09_SADS.pdf	125838 80bb628e3390daebf18e598243f72fd4ff1cfea8	no	9
Warnings:					
This is not an USPTO supplied ADS fillable form					
Information:					
10	Fee Worksheet (SB06)	fee-info.pdf	38597 a51e2cd9aec49d40c0ffa6f775addd2508a99bb0	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	4605442	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/148,722

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	22 minus 20 =	* 2			OR	x 80 =	160
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x 420 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1760

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
AMENDMENT A	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
AMENDMENT A	Application Size Fee (37 CFR 1.16(s))									
AMENDMENT A	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
AMENDMENT B	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
AMENDMENT B	Application Size Fee (37 CFR 1.16(s))									
AMENDMENT B	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/148,722	05/06/2016	Jamie E. Retterath	2806.03US09

CONFIRMATION NO. 4034

POA ACCEPTANCE LETTER

24113
PATTERSON THUENTE PEDERSEN, P.A.
4800 IDS CENTER
80 SOUTH 8TH STREET
MINNEAPOLIS, MN 55402-2100

OC000000086002699

Date Mailed: 09/23/2016

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 09/16/2016.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/yteferra/

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UNITED STATES DEPARTMENT OF COMMERCE
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Alexandria, Virginia 22313-1450
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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
15/148,722	05/06/2016	2872	1900	2806.03US09	22	3

CONFIRMATION NO. 4034

UPDATED FILING RECEIPT

24113
PATTERSON THUENTE PEDERSEN, P.A.
4800 IDS CENTER
80 SOUTH 8TH STREET
MINNEAPOLIS, MN 55402-2100

OC000000086008767

Date Mailed: 09/23/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

James E. Retterath, Excelsior, MN;
Robert A. Laumeyer, Eden Prairie, MN;

Applicant(s)

Facet Technology Corp., Eden Prairie, MN;

Power of Attorney: The patent practitioners associated with Customer Number 24113

Domestic Priority data as claimed by applicant

This application is a CON of 14/512,735 10/13/2014 PAT 9335255
which is a CON of 14/025,614 09/12/2013 PAT 8860944
which is a DIV of 13/205,337 08/08/2011 PAT 8660311
which is a DIV of 12/419,843 04/07/2009 PAT 7995796
which is a CON of 11/056,926 02/11/2005 PAT 7515736
which is a CON of 09/928,218 08/10/2001 PAT 6891960
which claims benefit of 60/224,761 08/12/2000
and claims benefit of 60/296,596 06/07/2001

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 05/19/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/148,722**

Projected Publication Date: 12/29/2016

Non-Publication Request: No

Early Publication Request: No
Title

System and Assessment of Reflective Objects Along a Roadway

Preliminary Class

359

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

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PLUS Search Results for S/N 15148722, Searched Thu Dec 22 12:53:24 EST 2016

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/148,722	05/06/2016	James E. Retterath	2806.03US09

CONFIRMATION NO. 4034

24113
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

PUBLICATION NOTICE

OC000000088178316

Title: System and Assessment of Reflective Objects Along a Roadway

Publication No.US-2016-0377529-A1
Publication Date:12/29/2016

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Notice of References Cited	Application/Control No. 15/148,722	Applicant(s)/Patent Under Reexamination RETTERATH ET AL.	
	Examiner /MICHAEL P. STAFIRA/	Art Unit 2886	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-6,711,280 B2	03-2004	Stafsudd; Oscar M.	G06K9/3241	348/622
*	B	US-2012/0065940 A1	03-2012	Retterath; James E.	G08G1/096758	702/189
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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United States Patent and Trademark Office
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NOTICE OF ALLOWANCE AND FEE(S) DUE

24113 7590 01/09/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

EXAMINER
STAFIRA, MICHAEL PATRICK

ART UNIT	PAPER NUMBER
2886	

DATE MAILED: 01/09/2017

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

TITLE OF INVENTION: System and Assessment of Reflective Objects Along a Roadway

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	04/10/2017

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24113 7590 01/09/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

TITLE OF INVENTION: System and Assessment of Reflective Objects Along a Roadway

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	04/10/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS
STAFIRA, MICHAEL PATRICK	2886	356-445000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

24113 7590 01/09/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

EXAMINER
STAFIRA, MICHAEL PATRICK

ART UNIT	PAPER NUMBER
2886	

DATE MAILED: 01/09/2017

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 15/148,722	Applicant(s) RETTERATH ET AL.	
	Examiner /MICHAEL P. STAFIRA/	Art Unit 2886	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *filing date 5/6/2016*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *20-41*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Allowable Subject Matter

2. Claims 20-41 are allowed over the prior art of record.

3. The following is an examiner's statement of reasons for allowance:

Regarding claim 20, the prior art fails to disclose or make obvious 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 having 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, and in combination with the other recited limitations of claim 20. Claims 21-27 are allowed by the virtue of dependency on the allowed claim 20.

Regarding claim 28, the prior art fails to disclose or make obvious an automated system for assessing reflective surfaces disposed along a roadway having 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, and in combination with the other recited limitations of claim 28. Claims 29-35 are allowed by the virtue of dependency on the allowed claim 28.

Regarding claim 36, the prior art fails to disclose or make obvious an automated method for assessing reflective surface disposed along a roadway having the steps of 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 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 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, and in combination with the other recited limitations of claim 36. Claims 37-41 are allowed by the virtue of dependency on the allowed claim 36.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to /MICHAEL P. STAFIRA/ whose telephone number is (571)272-2430. The examiner can normally be reached on 4/10 Schedule Mon, Tues, Weds, Fri.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tarifur Chowdhury can be reached on 571-272-2800 ext. 77. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL P STAFIRA/
Primary Examiner
Art Unit 2886

December 22, 2016

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
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BIB DATA SHEET

CONFIRMATION NO. 4034

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
15/148,722	05/06/2016 RULE	356	2886	2806.03US09

APPLICANTS
Facet Technology Corp., Eden Prairie, MN;

INVENTORS
James E. Retterath, Excelsior, MN;
Robert A. Laumeyer, Eden Prairie, MN;

**** CONTINUING DATA ****************************
This application is a CON of 14/512,735 10/13/2014 PAT 9335255
which is a CON of 14/025,614 09/12/2013 PAT 8860944
which is a DIV of 13/205,337 08/08/2011 PAT 8660311
which is a DIV of 12/419,843 04/07/2009 PAT 7995796
which is a CON of 11/056,926 02/11/2005 PAT 7515736
which is a CON of 09/928,218 08/10/2001 PAT 6891960
which claims benefit of 60/224,761 08/12/2000
and claims benefit of 60/296,596 06/07/2001

**** FOREIGN APPLICATIONS ****************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
05/19/2016

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /MICHAEL PATRICK STAFIRA/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		MN	18	22	3

ADDRESS
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100
UNITED STATES

TITLE
System and Assessment of Reflective Objects Along a Roadway

FILING FEE RECEIVED		
1900	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

CPC- SEARCHED

Symbol	Date	Examiner
G02B27/0172 OR G02B2027/0178 OR G02B2027/014 OR G02B2027/0138 OR G02B2027/0187 OR G02B27/017 OR G02B2027/0132 OR G02B26/0808 OR G02B26/0816 OR G02B2027/0174 OR G02B27/0093 OR G02B27/225 OR G02B6/005 O	12/22/2016	/MS/

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
East	12/22/2016	/MS/
NPL	12/22/2016	/MS/
Inventor Search (Palm)reviewed 09/928218, 11/056926, 12/419843, 13/205337, 14/025614, 14/512735	12/22/2016	/MS/
PLUS	12/22/2016	/MS/

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
G01N	21/251, 55, 84, 2201/102, 12, 06113	12/22/2016	/MS/
G01S	17/06	12/22/2016	/MS/
G06K	9/00818, 2036, 4652, 4661	12/22/2016	/MS/

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

CPC						
Symbol					**Type**	**Version**
G01N		21	/	251	F	2013-01-01
G01S		17	/	06	I	2013-01-01
G01N		21	/	55	I	2013-01-01
G01N		21	/	84	I	2013-01-01
G06K		9	/	00818	I	2013-01-01
G06K		9	/	2036	I	2013-01-01
G06K		9	/	4652	I	2013-01-01
G06K		9	/	4661	I	2013-01-01
G01N		2201	/	12	A	2013-01-01
G01N		2201	/	06113	A	2013-01-01
G01N		2201	/	102	A	2013-01-01
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CPC Combination Sets							
Symbol				**Type**	**Set**	**Ranking**	**Version**
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NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	22	
/MICHAEL P STAFIRA/ Primary Examiner.Art Unit 2886	12/22/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

U.S. Patent and Trademark Office

Part of Paper No. 20161222

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION									
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED				
356	445	G	0	1	N	21 / 00 (2006.01.01)					

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				

NONE (Assistant Examiner) (Date)	Total Claims Allowed: 22	
/MICHAEL P STAFIRA/ Primary Examiner.Art Unit 2886 12/22/2016 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No. 20161222

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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	2		18	15	34										
	3		19	16	35										
	4	1	20	17	36										
	5	2	21	18	37										
	6	3	22	19	38										
	7	4	23	20	39										
	8	5	24	21	40										
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	11	8	27												
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	13	10	29												
	14	11	30												
	15	12	31												
	16	13	32												

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 22	
/MICHAEL P STAFIRA/ Primary Examiner.Art Unit 2886 (Primary Examiner)	12/22/2016 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No. 20161222

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	30893	(road adj2 (mark$3 or sign))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 07:50
L2	9253	1 and image	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 07:51
L3	5635	2 and (camera or ccd)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 07:51
L4	1263	3 and light adj2 source	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 07:52
L5	281	4 AND ((G02B27/0172 OR G02B2027/0178 OR G02B2027/014 OR G02B2027/0138 OR G02B2027/0187 OR G02B27/017 OR G02B2027/0132 OR G02B26/0808 OR G02B26/0816 OR G02B2027/0174 OR G02B27/0093 OR G02B27/225 OR G02B6/005 OR G02B2027/0118 OR G02B2027/0127 OR G02B2027/0134 OR G02B27/2242 OR G02B5/04 OR G02B6/0051 OR G02B6/0068 OR G02B19/0042 OR G02B2027/011 OR G02B2027/0154 OR G02B2027/0183 OR G02B26/00 OR G02B26/0825 OR G02B26/0833 OR G02B26/0866 OR G02B26/0875 OR G02B26/101 OR G02B27/0012 OR G02B27/01 OR G02B27/0101 OR G02B27/0149 OR G02B27/0179 OR G02B27/0905 OR G02B27/0927 OR G02B27/141 OR G02B27/2278 OR G02B27/30 OR G02B5/128 OR G02B5/18 OR G02B5/1842 OR G02B5/28 OR G02B6/0001 OR G02B6/001 OR G02B6/0035 OR G02B6/0036 OR	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 07:53

		G02B6/0038 OR G02B6/0055 OR G02B6/0065 OR G02B6/0066 OR G02B6/0073 OR G02B6/0085 OR G01J1/04 OR G01J1/0407 OR G01J1/32 OR G01J1/4228 OR G01J2001/4247 OR G01J2003/2836 OR G01J3/02 OR G01J3/0205 OR G01J3/0208 OR G01J3/18 OR G01J3/28 OR G01J3/2803 OR G01J3/2823 OR G01J3/46 OR G01N2021/551 OR G01N21/55).CPC.)				
L6	386	road adj sign adj3 recognition	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 09:38
L7	294	6 and image	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 09:38
L8	234	7 and (camera or ccd)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 09:38
L9	18	8 AND ((G01N21/251 OR G01N21/55 OR G01N21/84 OR G01N2201/06113 OR G01N2201/12 OR G01N21/95607 OR G01B11/026 OR G02B2027/0123 OR G02B2027/013 OR G02B2027/0141 OR G02B27/0101).CPC.)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 09:39
L10	101	reflective adj3 recognition	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 09:42
L11	61	10 and image	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/12/22 09:42

12/22/2016 9:43:16 AM
C:\Users\mstafira\Documents\EAST\Workspaces\mike11.wsp

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/22/2016								
	1	-								
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
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✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
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CLAIM		DATE								
Final	Original	12/22/2016								
	37	=								
	38	=								
	39	=								
	40	=								
	41	=								

Electronic Acknowledgement Receipt	
EFS ID:	28055783
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	James E. Retterath
Customer Number:	24113
Filer:	Bradley Pedersen/Michelle Arcand
Filer Authorized By:	Bradley Pedersen
Attorney Docket Number:	2806.03US09
Receipt Date:	13-JAN-2017
Filing Date:	06-MAY-2016
Time Stamp:	11:04:09
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$1200
RAM confirmation Number	011317INTEFSW11050200
Deposit Account	160631
Authorized User	Bradley Pedersen
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	2806_03US09_RCE.pdf	797911 cc07269175fb944364d1a9c29d0e8cd81e6e7313	no	3
Warnings:					
Information:					
2	Transmittal Letter	2806_03US09_IDSLTR.pdf	737049 451c5ee006f26ccaf60907b8577facd006bbc17a	no	3
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Form (SB08)	2806_03US09_PTO1449.pdf	212598 cea8af18ca979963e41558efaa291b42dae0d86b	no	18
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
4	Other Reference-Patent/App/Search documents	IFW14512735_NPL.pdf	14707031 ef6b0ff15bd8328581b633e1f3f95b902c1306d5	no	329
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	30593 07ecb0abd9b76bb0a479d24ecb06366bf47b6c16	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	16485182	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	1	of	18	Attorney Docket Number	2806.03US09

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EXAMINER INITIAL*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
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				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
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		Application and File History for U.S. Patent Application No. 11/122,969, filed May 5, 2005, now U.S. Patent No. 7,590,310, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 09/177,836, filed October 23, 1998, now U.S. Patent No. 6,266,442, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 09/772,191, filed January 29, 2001, now U.S. Patent No. 6,449,384, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 09/812,753, filed March 20, 2001, now U.S. Patent No. 6,453,056, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 09/883,816, filed June 18, 2001, now U.S. Patent No. 6,363,161, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 10/244,318, filed September 16, 2002, now U.S. Patent No. 6,625,315, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 10/634,630, filed August 5, 2003, now U.S. Patent No. 7,092,548, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 11/457,255, filed July 13, 2006, now U.S. Patent No. 7,444,003, Inventors Laumeyer et al., *as available on PAIR at www.uspto.gov.*	

EXAMINER SIGNATURE		DATE CONSIDERED	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 120 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*				*Complete if Known*	
				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	17	of	18	Attorney Docket Number	2806.03US09

NON PATENT LITERATURE DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
		Application and File History for U.S. Patent Application No. 09/928,218, filed August 10, 2001, now U.S. Patent No. 6,891,960, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 11/056,926, filed February 11, 2005, now U.S. Patent No. 7,515,736, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 12/419,843, filed April 7, 2009, now U.S. Patent No. 7,995,796, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 09/918,375, filed July 30, 2001, now U.S. Patent No. 6,674,878, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 10/736,454, filed December 15, 2003, now U.S. Patent No. 7,043,057, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 11/381,503, filed May 3, 2006, now U.S. Patent No. 7,173,707, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 11/702,421, filed February 5, 2007, now U.S. Patent No. 7,411,681, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 12/584,894, filed September 14, 2009, now U.S. Patent No. 8,150,216, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 13/781,017, filed February 28, 2013, Inventors Retterath et al., *as available in PAIR at www.uspto.gov.*	

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				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	18	of	18	Attorney Docket Number	2806.03US09

NON PATENT LITERATURE DOCUMENTS

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		Application and File History for U.S. Patent Application No. 13/205,337, filed August 8, 2011, now U.S. Patent No. 8,660,311. Inventors Retterath et al., *as available in PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 14/025,614, filed September 12, 2013, now U.S. Patent No. 8,860,944. Inventors Retterath et al., *as available in PAIR at www.uspto.gov.*	
		Application and File History for U.S. Patent Application No. 14/512,735, filed October 13, 2014, now U.S. Patent No. 9,335,255. Inventors Retterath et al., *as available in PAIR at www.uspto.gov.*	

EXAMINER SIGNATURE		DATE CONSIDERED	

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If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

Electronic Patent Application Fee Transmittal

Application Number:	15148722
Filing Date:	06-May-2016
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	James E. Retterath
Filer:	Bradley Pedersen/Michelle Arcand
Attorney Docket Number:	2806.03US09

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
RCE- 1st Request	1801	1	1200	1200
		Total in USD ($)		**1200**

PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 2806.03US09

Retterath et al. Confirmation No.: 4034

Application No.: 15/148,722 Examiner: Michael P. Stafira

Filed: May 6, 2016 Group Art Unit: 2886

For: SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

Pursuant to 37 CFR § 1.56, the attention of the Patent and Trademark Office is hereby directed to the references listed on the attached Form PTO-1449. It is respectfully requested that the information be expressly considered during the prosecution of the above-referenced application, and be made of record therein and appear among the "References Cited" on any patent to issue therefrom.

The listing of a reference herein is not an admission that the reference is prior art or is material to patentability. 37 CFR § 1.97(h). Applicant reserves the right to establish the patentability of any claimed invention over any of the information provided herewith, and/or prove that this information may not be prior art, and/or prove that this information may not be enabling for any aspect of the information provided herewith.

This Information Disclosure Statement is being filed without a certification or fee because this Information Disclosure Statement is being filed before the mailing date of a first Office Action after (or with) the filing of a Request for Continued Examination under 37 CFR § 1.114. No certification or fee is required. 37 CFR § 1.97(b)(4).

The Examiner's attention is directed to the applications or patents, if any, to which priority is claimed, as well as to any continuing applications which claim priority to the above-referenced application, and to applications, if any, that may be related by virtue of similar claimed subject matter as the above-referenced application (collectively, the "Related Case(s)"). The Related Case(s), or documents associated with the Related Case(s), are identified on the attached form PTO-1449 by serial number, publication number and/or patent number, along with a copy of the current prosecution history, downloaded from PAIR where available. The current prosecution history for the Related Case(s) is submitted as an NPL document for the convenience of the Examiner.

The prosecution history for any and all of these Related Case(s) may include information material to patentability of the above-referenced application including Office Actions, Responses, Office Communications or Notices of Allowance, all of which are readily accessible to the Examiner via PAIR/PALM. To promote consistency and full disclosure during the prosecution of the above-referenced application together with the prosecution of any of the Related Case(s) and to assist the Examiner in complying with the obligations of MPEP 609.02 and/or 2001.06(b), the Examiner is respectfully requested to review the prosecution history of each of the Related Case(s). **This request for review should be considered ongoing throughout the prosecution of the above-referenced application with an updated review via**

PAIR/PALM of the prosecution histories of any Related Case(s) being made prior to issuance of any Notice of Allowance for the above-referenced application. The identification of any of the Related Case(s) for purposes of this Information Disclosure Statement should not be construed as a waiver of secrecy, if applicable, as to such applications now or upon issuance of the above-referenced application as a patent. For purposes of the Related Case(s), it should be noted that all of the Related Case(s) are published or otherwise publicly available on PAIR.

Please note that copies of the references that were cited by or submitted to the Office in applications which are relied upon for an earlier filing date under 35 U.S.C. § 120 may be found in the appropriate records via PAIR/PALM. 37 CFR § 1.98(d).

Respectfully submitted,

Brad D. Pedersen
Registration No. 32432

Customer No. 24113
Patterson Thuente Pedersen, P.A.
4800 IDS Center
80 South 8th Street
Minneapolis, Minnesota 55402-2100
Telephone: 612.349.5774

Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 16-0631.

Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	15148722	Filing Date	2016-05-06	Docket Number (if applicable)	2806.03US09	Art Unit	2886
First Named Inventor	Retterath et al.			Examiner Name	Michael P. Stafira		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the orde in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

☐ Other _____

☒ Enclosed

☐ Amendment/Reply

☒ Information Disclosure Statement (IDS)

☐ Affidavit(s)/ Declaration(s)

☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____
(Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.
☒ The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 160631

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

X Patent Practitioner Signature

Applicant Signature

PTO/SB/30EFS (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Signature of Registered U.S. Patent Practitioner			
Signature	/Brad Pedersen/	Date (YYYY-MM-DD)	2017-01-13
Name	Brad Pedersen	Registration Number	32432

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If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the informatio solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record ma be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	1	of	2	Attorney Docket Number	2806.03US09

U.S. PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
		US-5,643,476 A	07-01-1997	Garmire et al.
		US-5,812,267 A	09-22-1998	Everett, Jr. et al.
		US-		
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FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	T[6]

EXAMINER SIGNATURE		DATE CONSIDERED	

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[1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language Translation is attached.

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				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	2	of	2	Attorney Docket Number	2806.03US09

NON PATENT LITERATURE DOCUMENTS

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		Long, Michigan DOT Reflects on Signs, October 1997 [retrieved 01/11/2017], Transportation Research Board, Issue 192, pp. 24-25. Retrieved from the Internet: https://trid.trb.org/view.aspx?id=474202.	
		Lumia, A mobile system for measuring retroreflectance of traffic signs, March 1, 1991 [retrieved 01/11/2017], Proc. SPIE, Optics, Illumination, and Image Sensing for Machine Vision V, Vol. 1385, pp. 15-26. Retrieved from the Internet: http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=954038.	

EXAMINER SIGNATURE		DATE CONSIDERED	

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of: Attorney Docket No.: 2806.03US09

Retterath et al. Confirmation No.: 4034

Application No.: 15/148,722 Examiner: Michael P. Stafira

Filed: May 6, 2016 Group Art Unit: 2886

For: SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

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Respectfully submitted,

Brad D. Pedersen
Registration No. 32432

Customer No. 24113
Patterson Thuente Pedersen, P.A.
4800 IDS Center
80 South 8th Street
Minneapolis, Minnesota 55402-2100
Telephone: 612.349.5774

Please grant any extension of time necessary for entry; charge any fee due to Deposit Account No. 16-0631.

Electronic Acknowledgement Receipt

EFS ID:	28120676
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	James E. Retterath
Customer Number:	24113
Filer:	Bradley Pedersen/Michelle Arcand
Filer Authorized By:	Bradley Pedersen
Attorney Docket Number:	2806.03US09
Receipt Date:	20-JAN-2017
Filing Date:	06-MAY-2016
Time Stamp:	14:11:11
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	2806_03US09_SIDSLTR.pdf	395251 b6292882f0acdb79694c5c437f4671575830 0f4d	no	2

Warnings:

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	2806_03US09_PTO1449.pdf	107715 abf9d233fe3a42aa4288a3acb98dbb2901a04439	no	2
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Non Patent Literature	Long_MichiganDOTReflectsOnSigns_NPL.pdf	560362 0360dfcba44924db45ce56a88c2bad47ccdf9b1c	no	2
Warnings:					
Information:					
4	Non Patent Literature	Lumia_AMobileSystemForMeasuringRetroreflectance_NPL.pdf	2330126 25c1bf2a6c675739a6cea22db311b5a8c9f19e3b	no	12
Warnings:					
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			Total Files Size (in bytes):	3393454	

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<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PLUS Search Results for S/N 15148722, Searched Thu Feb 02 12:48:06 EST 2017

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

CPC						
Symbol					**Type**	**Version**
G01N		21	/	251	F	2013-01-01
G08G		1	/	096758	I	2013-01-01
G08G		1	/	096783	I	2013-01-01
G01N		21	/	55	I	2013-01-01
G01N		21	/	84	I	2013-01-01
G01N		2201	/	06113	A	2013-01-01
G01N		2201	/	12	A	2013-01-01
G01S		17	/	06	I	2013-01-01
G01N		2201	/	102	A	2013-01-01
G06K		9	/	00818	I	2013-01-01
G06K		9	/	2036	I	2013-01-01
G06K		9	/	4652	I	2013-01-01
G06K		9	/	4661	I	2013-01-01
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CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
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NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	22	
/MICHAEL P STAFIRA/ Primary Examiner.Art Unit 2886	2/2/2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION									
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED				
356	445	G	0	1	N	21 / 00 (2006.0)					

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				

NONE (Assistant Examiner)	(Date)	Total Claims Allowed: 22	
/MICHAEL P STAFIRA/ Primary Examiner.Art Unit 2886 (Primary Examiner)	2/2/2017 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office

Part of Paper No. 20170202

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		17	14	33										
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	16	13	32												

NONE (Assistant Examiner) (Date)		Total Claims Allowed: 22	
/MICHAEL P STAFIRA/ Primary Examiner.Art Unit 2886 (Primary Examiner) (Date)	2/2/2017	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No. 20170202

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	15/148,722
Filing Date	May 6, 2016
First Named Inventor	Retterath et al.
Art Unit	2886
Examiner Name	Michael P. Stafira
Attorney Docket Number	2806.03US09

Sheet	1	of	18

U.S. PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
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EXAMINER INITIAL*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	T[6]

EXAMINER SIGNATURE	/MICHAEL P STAFIRA/	DATE CONSIDERED	02/02/2017

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Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	2	of	18	Attorney Docket Number	2806.03US09

U.S. PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Document Number / Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
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FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Foreign Patent Document / Country Code[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	T[6]

EXAMINER SIGNATURE	/MICHAEL P STAFIRA/	DATE CONSIDERED	02/02/2017

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Substitute for form 1449/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)	Application Number	15/148,722
	Filing Date	May 6, 2016
	First Named Inventor	Retterath et al.
	Art Unit	2886
	Examiner Name	Michael P. Stafira
Sheet 3 of 18	Attorney Docket Number	2806.03US09

U.S. PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Document Number Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
/M.P.S/		US-5,818,640 A	10-06-1998	Watanabe et al.
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EXAMINER SIGNATURE	/MICHAEL P STAFIRA/	DATE CONSIDERED	02/02/2017

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Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	4	of	18	Attorney Docket Number	2806.03US09

U.S. PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Document Number / Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
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				Filing Date	May 6, 2016
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				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	5	of	18	Attorney Docket Number	2806.03US09

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EXAMINER SIGNATURE	/MICHAEL P STAFIRA/	DATE CONSIDERED	02/02/2017

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				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
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				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	14	of	18	Attorney Docket Number	2806.03US09

NON PATENT LITERATURE DOCUMENTS

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/M.P.S/		Application and File History for U.S. Patent Application No. 11/122,969, filed May 5, 2005, now U.S. Patent No. 7,590,310, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
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/M.P.S/		Application and File History for U.S. Patent Application No. 12/584,894, filed September 14, 2009, now U.S. Patent No. 8,150,216, Inventors Retterath et al., *as available on PAIR at www.uspto.gov.*	
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/M.P.S/		Application and File History for U.S. Patent Application No. 13/205,337, filed August 8, 2011, now U.S. Patent No. 8,660,311. Inventors Retterath et al., *as available in PAIR at www.uspto.gov.*	
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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	15708	("3D" adj2 (camera or sensor or detector))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 08:12
L2	17	1 and bonded adj2 wire	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 08:14
L3	12	2 and semiconductor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 10:05
L4	6	2 and wafer	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 10:05
L5	12	2 and substrate	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 10:06
L6	3377	1 and semiconductor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 10:06
L7	58	1 and semiconductor adj2 package	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 10:07
L8	37	1 and wafer adj2 inspect$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 10:41
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L10	140	9 and location	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2017/02/02 11:33
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STAFIRA, MICHAEL PATRICK

ART UNIT	PAPER NUMBER
2886	

DATE MAILED: 02/10/2017

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

TITLE OF INVENTION: System and Assessment of Reflective Objects Along a Roadway

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	05/10/2017

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If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24113 7590 02/10/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

TITLE OF INVENTION: System and Assessment of Reflective Objects Along a Roadway

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	05/10/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS
STAFIRA, MICHAEL PATRICK	2886	356-445000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

24113 7590 02/10/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

EXAMINER
STAFIRA, MICHAEL PATRICK

ART UNIT	PAPER NUMBER
2886	

DATE MAILED: 02/10/2017

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 15/148,722	Applicant(s) RETTERATH ET AL.	
	Examiner /MICHAEL P. STAFIRA/	Art Unit 2886	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *RCE filed 1/13/2017*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *20-41*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 1/20/2017; 1/13/2017
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Allowable Subject Matter

2. Claims 20-41 are allowed over the prior art of record.

3. The following is an examiner's statement of reasons for allowance:

Regarding claim 20, the prior art fails to disclose or make obvious an automated system that detects and determines reflective surfaces of interest in a scene of non-retrorelective surfaces along a. roadway ,hat is being traversed by a vehicle, the automated system having an image capture system that captures images within a field of view along the roadway; 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, and in combination with the other recited limitations of claim 20. Claims 21-28 are allowed by the virtue of dependency on the allowed claim 20.

Regarding claim 28, the prior art fails to disclose or make obvious an automated system for assessing reflective surfaces disposed along a roadway having 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; 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, and in combination with the other recited limitations of claim 28. Claims 29-35 are allowed by the virtue of dependency on the allowed claim 28.

Regarding claim 36, the prior art fails to disclose or make obvious a method for assessing reflective surface disposed along a roadway having the steps of 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 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 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, and in combination with the other recited limitations of claim 36. Claims 37-41 are allowed by the virtue of dependency on the allowed claim 36.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to /MICHAEL P. STAFIRA/ whose telephone number is (571)272-2430. The examiner can normally be reached on 4/10 Schedule Mon, Tues, Weds, Fri.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Tarifur Chowdhury can be reached on 571-272-2800 ext. 77. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MICHAEL P STAFIRA/
Primary Examiner
Art Unit 2886

February 2, 2017

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

CPC- SEARCHED

Symbol	Date	Examiner
G02B27/0172 OR G02B2027/0178 OR G02B2027/014 OR G02B2027/0138 OR G02B2027/0187 OR G02B27/017 OR G02B2027/0132 OR G02B26/0808 OR G02B26/0816 OR G02B2027/0174 OR G02B27/0093 OR G02B27/225 OR G02B6/005 O	2/2/2017	/MS/

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
East	2/2/2017	/MS/
NPL	2/2/2017	/MS/
Inventor Search (Palm)reviewed 09/928218, 11/056926, 12/419843, 13/205337, 14/025614, 14/512735	12/22/2016	/MS/
PLUS	2/2/2017	/MS/

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
G01N	21/251, 55, 84, 2201/102, 12, 06113	2/2/2017	/MS/
G01S	17/06	2/2/2017	/MS/
G06K	9/00818, 2036, 4652, 4661	2/2/2017	/MS/

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/22/2016	02/02/2017							
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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	15148722	RETTERATH ET AL.
	Examiner	**Art Unit**
	MICHAEL P STAFIRA	2886

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	12/22/2016	02/02/2017							
	37	=	=							
	38	=	=							
	39	=	=							
	40	=	=							
	41	=	=							

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	15/148,722
Filing Date	May 6, 2016
First Named Inventor	Retterath et al.
Art Unit	2886
Examiner Name	Michael P. Stafira
Attorney Docket Number	2806.03US09

Sheet	1	of	2

U.S. PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
/M.P.S/		US-5,643,476 A	07-01-1997	Garmire et al.
/M.P.S/		US-5,812,267 A	09-22-1998	Everett, Jr. et al.
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FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	T[6]

EXAMINER SIGNATURE	/MICHAEL P STAFIRA/	DATE CONSIDERED	02/02/2017

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6]Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.P.S/

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT *(Use as many sheets as necessary)*				*Complete if Known*	
				Application Number	15/148,722
				Filing Date	May 6, 2016
				First Named Inventor	Retterath et al.
				Art Unit	2886
				Examiner Name	Michael P. Stafira
Sheet	2	of	2	Attorney Docket Number	2806.03US09

NON PATENT LITERATURE DOCUMENTS

EXAMINER INITIAL*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published	T[2]
/M.P.S/		Long, Michigan DOT Reflects on Signs, October 1997 [retrieved 01/11/2017], Transportation Research Board, Issue 192, pp. 24-25. Retrieved from the Internet: https://trid.trb.org/view.aspx?id=474202.	
/M.P.S/		Lumia, A mobile system for measuring retroreflectance of traffic signs, March 1, 1991 [retrieved 01/11/2017], Proc. SPIE, Optics, Illumination, and Image Sensing for Machine Vision V, Vol. 1385, pp. 15-26. Retrieved from the Internet: http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=954038.	

EXAMINER SIGNATURE	/MICHAEL P STAFIRA/	DATE CONSIDERED	02/02/2017

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 120 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450 Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.P.S/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 4034

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
15/148,722	05/06/2016 RULE	356	2886	2806.03US09

APPLICANTS
Facet Technology Corp., Eden Prairie, MN;

INVENTORS
James E. Retterath, Excelsior, MN;
Robert A. Laumeyer, Eden Prairie, MN;

**** CONTINUING DATA ****************************
This application is a CON of 14/512,735 10/13/2014 PAT 9335255
which is a CON of 14/025,614 09/12/2013 PAT 8860944
which is a DIV of 13/205,337 08/08/2011 PAT 8660311
which is a DIV of 12/419,843 04/07/2009 PAT 7995796
which is a CON of 11/056,926 02/11/2005 PAT 7515736
which is a CON of 09/928,218 08/10/2001 PAT 6891960
which claims benefit of 60/224,761 08/12/2000
and claims benefit of 60/296,596 06/07/2001

**** FOREIGN APPLICATIONS ****************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
05/19/2016

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /MICHAEL PATRICK STAFIRA/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		MN	18	22	3

ADDRESS
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100
UNITED STATES

TITLE
System and Assessment of Reflective Objects Along a Roadway

FILING FEE RECEIVED		
1900	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

BIB (Rev. 05/07).

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

29113 7590 02/10/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	05/06/2016	James E. Retterath	2806.03US09	4034

TITLE OF INVENTION: System and Assessment of Reflective Objects Along a Roadway

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	05/10/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS
STAFIRA, MICHAEL PATRICK	2886	356-445000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Patterson Thuente
2 Pedersen, P.A.
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Facet Technology Corp.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Eden Prairie, MN

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies .....

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☒ Payment by credit card. ~~XXXXXXXXXXXXXXXX~~.
- ☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 160631 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature ..... Date 4/25/17

Typed or printed name Brad Pedersen ..... Registration No. 32432

Electronic Acknowledgement Receipt	
EFS ID:	29016899
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	James E. Retterath
Customer Number:	24113
Filer:	Bradley Pedersen/Michelle Arcand
Filer Authorized By:	Bradley Pedersen
Attorney Docket Number:	2806.03US09
Receipt Date:	25-APR-2017
Filing Date:	06-MAY-2016
Time Stamp:	10:53:58
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$960
RAM confirmation Number	042517INTEFSW10550100
Deposit Account	160631
Authorized User	Bradley Pedersen
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	2806_03US09_ISSUEFEE.pdf	475737 f9c0c02abd5e7c922905cdab9849b569c1bad9dd	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30647 a9c0e23d01bd7a92b7150d84ac51fbea2a0595c2	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	506384	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Electronic Patent Application Fee Transmittal

Application Number:	15148722
Filing Date:	06-May-2016
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	James E. Retterath
Filer:	Bradley Pedersen/Michelle Arcand
Attorney Docket Number:	2806.03US09

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**960**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/148,722	06/06/2017	9671328	2806.03US09	4034

24113 7590 05/17/2017
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

James E. Retterath, Excelsior, MN;
Facet Technology Corp., Eden Prairie, MN;
Robert A. Laumeyer, Eden Prairie, MN;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

IR103 (Rev. 10/09)

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	James	E.	Retterath	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Excelsior	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	c/o Facet Technology Corp.
Address 2	6517 City West Parkway
City	Eden Prairie
State/Province	MN
Postal Code	55344
Country	US

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Robert	A.	Laumeyer	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Eden Prairie	State/Province	MN	Country of Residence	US

Mailing Address of Inventor:

Address 1	c/o Facet Technology Corp.
Address 2	6517 City West Parkway
City	Eden Prairie
State/Province	MN
Postal Code	55344
Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

PTO/AIA/14 (11-15)
Approved for use through 04/30/2017. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

☐ An Address is being provided for the correspondence Information of this application.			
Customer Number	~~24113~~ 23524		
Email Address	~~pedersen@ptslaw.com~~ ipdocketing@foley.com	Add Email	Remove Email

Application Information:

Title of the Invention	System and Assessment of Reflective Objects Along a Roadway		
Attorney Docket Number	~~2806.03US09~~ 116139-0106	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)		Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	~~24413~~ 23524		

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03UC09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
15/148722	Continuation of	14/512735	2014-10-13

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/512735	Continuation of	14/025614	2013-09-12	8860944	2014-10-14

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/025614	Division of	13/205337	2011-08-08	8660311	2014-02-25

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
13/205337	Division of	12/419843	2009-04-07	7995796	2011-08-09

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
12/419843	Continuation of	11/056926	2005-02-11	7515736	2009-04-07

Prior Application Status	Patented				Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
11/056926	Continuation of	09/928218	2001-08-10	6891960	2005-05-10

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
09/928218	Claims benefit of provisional	60/224761	2000-08-12

Prior Application Status	Expired		Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
09/928218	Claims benefit of provisional	60/296596	2001-06-07

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2896.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. **Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. **Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

○ Assignee ○ Legal Representative under 35 U.S.C. 117 ○ Joint Inventor

○ Person to whom the inventor is obligated to assign. ○ Person who shows sufficient proprietary interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

Organization Name	~~Facet Technology Corp.~~ Mandli Communications, Inc.		
Mailing Address Information For Applicant:			
Address 1	~~6517 City West Parkway~~ 2655 Research Park Drive		
Address 2			
City	~~Eden Prairie~~ Fitchburg	**State/Province**	~~MN~~ Wisconsin
Country	US	Postal Code	~~55344~~ 53711
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	Given Name	Middle Name	Family Name	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	~~/Brad Pedersen/~~ /Nicholas M. Lagerwall/			Date (YYYY-MM-DD)	~~2016-09-16~~ August 10, 2017
First Name	~~Brad~~ Nicholas	Last Name	~~Pedersen~~ Lagerwall	Registration Number	~~32432~~ 63272

Additional Signature may be generated within this form by selecting the Add button.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	~~2806.03US09~~ 116139-0106
	Application Number	15/148722
Title of Invention	System and Assessment of Reflective Objects Along a Roadway	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

[■] Practitioners associated with Customer Number: 23524

OR

[ ] Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

[■] The address associated with Customer Number: 23524

OR

[ ] Firm or Individual Name			
Address			
City		State	Zip
Country			
Telephone		Email	

Assignee Name and Address: MANDLI COMMUNICATIONS, INC.
2655 Research Park Drive
Fitchburg, Wisconsin 53711

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature	[signature]	Date	8/8/17
Name	Raymond J. Mandli	Telephone	608-835-3500
Title	President		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	30063892
Application Number:	15148722
International Application Number:	
Confirmation Number:	4034
Title of Invention:	System and Assessment of Reflective Objects Along a Roadway
First Named Inventor/Applicant Name:	James E. Retterath
Customer Number:	24113
Filer:	Nicholas M. Lagerwall/Dana Moore-Galloway
Filer Authorized By:	Nicholas M. Lagerwall
Attorney Docket Number:	2806.03US09
Receipt Date:	14-AUG-2017
Filing Date:	06-MAY-2016
Time Stamp:	08:27:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		15148722_Statementunder37CFR373c.pdf	477791 b38df97ee4b79709625eff84ed20ff811ecfeff3	yes	12

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Assignee showing of ownership per 37 CFR 3.73	1	2
	Application Data Sheet	3	11
	Power of Attorney	12	12
Warnings:			
Information:			
	Total Files Size (in bytes):	477791	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.
<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.
<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Mandli Communications, Inc. Attorney Docket No.: 116139-0106

Application No./Patent No.: 15/148722 Filed/Issue Date: 05/06/2016

Titled: SYSTEM AND ASSESSMENT OF REFLECTIVE OBJECTS ALONG A ROADWAY

Mandli Communications, Inc., a Corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☐ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☑ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: James E. RETTERATH et al. To: Facet Technology Corp.

The document was recorded in the United States Patent and Trademark Office at

Reel 039735, Frame 0371, or for which a copy thereof is attached.

2. From: Facet Technology Corp. To: Mandli Inc.

The document was recorded in the United States Patent and Trademark Office at

Reel 043072, Frame 0281, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: Facet Technology Corporation To: Mandli Communications, Inc.

The document was recorded in the United States Patent and Trademark Office at
Reel 043133, Frame 0929, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☑ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Nicholas M. Lagerwall/	August 10, 2017
Signature	Date
Nicholas M. Lagerwall (Reg. No. 63,272)	Attorney for Applicant
Printed or Typed Name	Title or Registration Number

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/148,722	05/06/2016	James E. Retterath	2806.03US09

CONFIRMATION NO. 4034

POWER OF ATTORNEY NOTICE

24113
PATTERSON THUENTE PEDERSEN, P.A.
80 SOUTH 8TH STREET
4800 IDS CENTER
MINNEAPOLIS, MN 55402-2100

OC000000093505772

Date Mailed: 08/17/2017

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/14/2017.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/ldvan/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/148,722	05/06/2016	James E. Retterath	116139-0106

CONFIRMATION NO. 4034

POA ACCEPTANCE LETTER

23524
FOLEY & LARDNER LLP
3000 K STREET N.W.
SUITE 600
WASHINGTON, DC 20007-5109

OC000000093505783

Date Mailed: 08/17/2017

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/14/2017.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/ldvan/

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT7741876

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	RELEASE OF SECURITY INTEREST

CONVEYING PARTY DATA

Name	Execution Date
MONONA BANK	01/11/2023

RECEIVING PARTY DATA

Name:	MANDLI COMMUNICATIONS, INC.
Street Address:	2655 RESEARCH PARK DR
City:	FITCHBURG
State/Country:	WISCONSIN
Postal Code:	53711

PROPERTY NUMBERS Total: 8

Property Type	Number
Patent Number:	6891960
Patent Number:	7515736
Patent Number:	7995796
Patent Number:	8660311
Patent Number:	8860944
Patent Number:	9335255
Patent Number:	9671328
Patent Number:	9989457

CORRESPONDENCE DATA

Fax Number: (608)283-1709

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 6082579521
Email: docket_chussin@boardmanclark.com
Correspondent Name: CHRISTOPHER J. HUSSIN BOARDMAN & CLARK LLP
Address Line 1: 1 S. PINCKNEY STREET, STE. 410
Address Line 4: MADISON, WISCONSIN 53703

NAME OF SUBMITTER:	CHRISTOPHER J. HUSSIN
SIGNATURE:	/Chris hussin/
DATE SIGNED:	01/13/2023

	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 3
source=Security Release (A4768552x9DEB4)#page1.tif
source=Security Release (A4768552x9DEB4)#page2.tif
source=Security Release (A4768552x9DEB4)#page3.tif

RELEASE OF PATENT SECURITY INTEREST

This RELEASE OF PATENT SECURITY INTEREST ("**Release**") is made and effective as of January 11, 2023, and granted by Monona Bank (the "**Secured Party**"), in favor of Mandli Communications, Inc., (the "**Grantor**") and its successors, assigns and legal representatives.

WHEREAS, in connection with indebtedness related Loan No. 10021798-70371, dated as of August 15, 2017, by and between the Grantor and the Secured Party, the Grantor executed and delivered to the Secured Party a Commercial Security Agreement dated as of August 15, 2017 (the "**Security Agreement**");

WHEREAS, pursuant to the Security Agreement, the Grantor pledged and granted to the Secured Party a security interest in and to all of the right, title and interest of such Grantor in, to and under the Patent Collateral (as defined below);

WHEREAS, the Security Agreement was recorded with the United States Patent and Trademark Office at Reel 043389, Frame 0947 on August 24, 2017; and

WHEREAS, the Grantor has requested that the Secured Party enter into this Release in order to effectuate, evidence and record the release and reassignment to the Grantor of any and all right, title and interest the Secured Party may have in the Patent Collateral pursuant to the Security Agreement.

NOW THEREFORE, for good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Secured Party, its successors, legal representatives and assigns, hereby terminates the Security Agreement and terminates, releases and discharges any and all security interests that it has pursuant to the Security Agreement in any and all right, title and interest of the Grantor, and reassigns to the Grantor any and all right, title and interest that it may have, in, to and under the patents and patent applications described in Schedule A attached and patentable inventions and improvements disclosed or described therein (collectively, the "**Patents**"), all continuations, continuations-in-part, divisions, renewals, extensions, substitutions, reissuances and their legal equivalents of the Patents filed in the United States or in any foreign country for the full term or terms for which the same may be granted, in all rights to income, royalties, profits, awards, fees, payments, damages, licenses or other rights relating to the Patents, including the right to sue for past, present or future infringement, the right to make, use or sell the inventions disclosed or claimed therein, in all other rights and goodwill relating to the Patents, in all general intangibles, intellectual and other intangible or tangible property of Grantor of any kind or nature, associated with, arising from, pertaining to or accruing under any of the foregoing, including all rights provided by the law of any applicable jurisdiction in the United States, throughout the world and pursuant to international treaties and conventions and otherwise, and in all products, supporting obligations and proceeds of the foregoing (the "**Patent Collateral**").

[SIGNATURE PAGE FOLLOWS]

IN WITNESS WHEREOF, Grantor has caused this Release to be duly executed and delivered by its officer thereunto duly authorized as of the date first above written.

MONONA BANK

By: _____

Name: Ted Lundeson

Title: SVP

SCHEDULE A

PATENTS

Patents

Patent Numbers	Date of Patent	Application No.	Date Filed
US6891960	May 10, 2005	09/928,218	August 10, 2001
US7515736	April 7, 2009	11/056,926	February 11, 2005
US7995796	August 9, 2011	12/419,843	April 7, 2009
US8660311	February 25, 2014	13/205,337	August 8, 2011
US8860944	October 14, 2014	14/025,614	September 12, 2013
US9335255	May 10, 2016	14/512,735	October 13, 2014
US9671328	June 6, 2017	15/148,722	May 6, 2016

Patent Application

Application Serial Number	Date Filed	Patent Number
15/595,594	May 15, 2017	US9,989,457