



- (51) **International Patent Classification:**
G01N 21/55 (2014.01) **H01L 31/042** (2014.01)
B64D 15/20 (2006.01)
- (21) **International Application Number:**
PCT/CA2013/000698
- (22) **International Filing Date:**
7 August 2013 (07.08.2013)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
13/507,956 9 August 2012 (09.08.2012) US
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- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM,
ZW.

- (84) Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

- (54) Title:** REFLECTIVE MATERIAL SENSOR

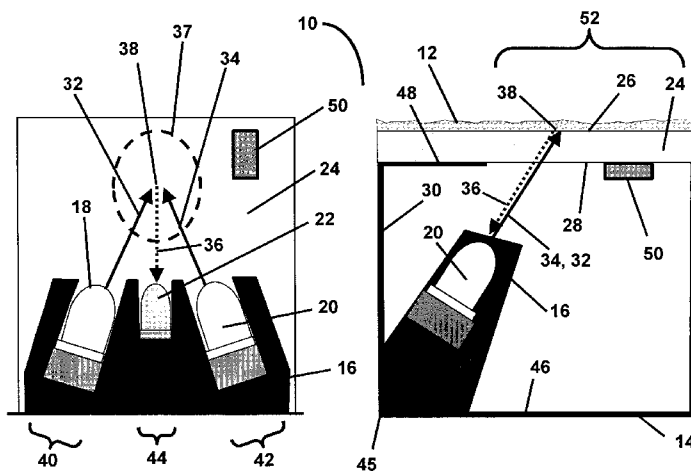


Figure 1A Top View

Figure 1B Side View

Figure 1

- (57) Abstract:** Described herein is a sensor for sensing reflective material. The sensor includes a housing with a transparent window and a sensor mount located in the housing and angled away from a housing wall. A radiation emitter is mounted in the sensor mount and emits radiation along an axis through the transparent window which has an amount of the reflective material located thereon. A radiation detector is mounted in the sensor mount and located adjacent the radiation emitter. The radiation detector is located to receive reflected radiation from the reflective material along another axis. The first axis is angled towards the second axis.

REFLECTIVE MATERIAL SENSOR

TECHNICAL FIELD

The present relates to material sensors, and more particularly to a sensor for
5 sensing reflective materials.

BACKGROUND

Precipitation sensors have been developed to determine the presence of water in its vapor, liquid and solid forms, but usually the sensor is immersed in the material. Non-immersed sensing is a significant challenge. One example
10 of a non-immersed sensor is the Bosch vehicle windshield rain sensor (Optical Sensor US Patent 6,376,824 by Michenfelder et al) used to operate windshield wipers. This sensor depends on the change in refraction of a reflected light beam against glass when water is on the outer glass surface. However, it has poor sensitivity for snow, unless the glass can be heated
15 enough to melt the snow next to the glass. This would be difficult to facilitate without making the vehicle occupants too uncomfortable and initially, in cold environments, would not work at all until the heating reached an acceptable level for the sensor to be engaged.

BRIEF SUMMARY

20 We have invented a sensor that uses a reflective rather than refractive technique, and as such is very well suited to determining the presence of winter precipitation such as snow, sleet, frost, ice or ice pellets. A radiation source such as a LED is oriented to radiate through a transparent material such as glass, at an angle that does not cause a surface reflection back to the
25 radiation sensor. When a reflective material such as winter precipitation is on the transparent material surface, a radiation sensor such as but not limited to a photo transistor, photo diode or light dependent resistor adjacent to the radiation source senses the radiation reflection.

Accordingly, there is provided a sensor for sensing reflective material, the sensor comprising:

- a housing having a transparent window;
- a sensor mount located in the housing and angled away from a housing wall;
- a radiation emitter mounted in the sensor mount for emitting radiation along a first axis through the transparent window, the transparent window having an amount of the reflective material located thereon; and
- a radiation detector mounted in the sensor mount and located adjacent the radiation emitter, the radiation detector being located to receive reflected radiation from the reflective material along a second axis, the first axis being angled towards the second axis.

In one example, the sensor includes two radiation emitters each located on either side of the radiation detector, the two radiation emitters being mounted to emit radiation along their respective first axes through the transparent window towards a common focal point on an outer surface of the transparent window. The sensor mount includes two spaced apart cavities aligned along the respective first axes in which the radiation emitters are located, and another cavity aligned along the second axis in which the radiation detector is located.

In one example, the sensor mount is located at a junction between the housing wall and a housing floor so that sensor mount is angled away from the housing wall.

In another example, a baffle extends into the housing from the housing wall. In another example, a temperature sensor is located on a lower surface of the transparent window.

In yet another example, a baffle wall extends into the housing from the housing wall; and a temperature sensor is located on a lower surface of the transparent window.

- 5 In one example, the radiation emitter is a Light Emitting Diode (LED).

In one example, the radiation sensor is a photo transistor or photo diode located adjacent to the radiation emitter so as to detect reflected radiation.

- 10 In another example, the radiation emitter is disposed so that radiation is emitted through the transparent window at an angle that does not cause a surface reflection back to the radiation detector. A controller is located in the housing and is connected to a variable resistor, the radiation detector, the radiation emitter and the temperature sensor. A controller is located in the
15 housing and is connected to a fixed resistor, the radiation detector, the radiation emitter and the temperature sensor.

- In one example, the radiation detector is an integrated circuit having a photo transistor, a photo diode or a light dependent resistor located adjacent to the
20 radiation emitter so as to detect reflected radiation.

In another example, the reflective material is winter precipitation. The winter precipitation is snow, sleet, frost, ice or ice pellets.

- 25 In one example, the reflective material is non-winter precipitation. The non-winter precipitation is reflective liquids, dirt, or particulate material suspended in liquids.

- In one example, the sensor is mounted for use on motorized transportation
30 including trucks, cars, motor bikes, recreational vehicles, trains, or boats.

In another example, the sensor is mounted for use on solar panels and trough reflectors.

In yet another example, the sensor is mounted for use on sidewalks,
5 driveways, walkways, roads, roofs, or infrastructure projects.

In another example, the sensor is mounted for use with greenhouses, atriums, windows, freezer glass doors, skylights; on planes, helicopters; food services, freezers /fridges, spacecraft, buildings; for landscaping such as grass and
10 garden maintenance, crops; or for weather determination, climate, ecosystem preservation; or for medical applications and storage of tissues and cells, sterilizations; or for food preparation and preservation, and the like.

In another example, the sensor is used in solar applications for building
15 materials including decking, walls or shingles.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the discovery may be readily understood, embodiments are illustrated by way of example in the accompanying drawings.

Figure 1A illustrates top view of a sensor;
20

Figure 1B illustrates a side view of the sensor showing radiation emitted and radiation reflected;

Figure 2 illustrates an exploded view of the sensor;
25

Figure 3 illustrates the sensor's field of view.

Figure 4 is diagrammatic representation of communication between sensor components in one example of the sensor; and
30

Figure 5 is diagrammatic representation of communication between sensor components in an alternative example of the sensor.

Further details of the device and its advantages will be apparent from the
5 detailed description included below.

DETAILED DESCRIPTION

Referring to Figures 1A, 1B and 2, there is illustrated generally at 10 a sensor for sensing reflective material 12. In one example, the reflective material is winter precipitation such as, for example, snow, frost, ice or ice pellets. In
10 another example, the reflective material is non-winter precipitation such as reflective liquids, dirt, or particulate material suspended in liquids. Broadly speaking, the sensor 10 includes a housing 14, a sensor mount 16, two radiation emitters (radiation sources) 18, 20, and a radiation detector (radiation sensor) 22. The housing 14 has a transparent window 24 which
15 includes an upper surface 26 and a lower surface 28 which is disposed towards the inside of the housing 14. The transparent window 24 has an amount of accumulated reflective material 12 located thereon. The sensor mount 16 is located in the housing 14 and angled away from a housing wall 30. The radiation emitters 18, 20 are mounted in the sensor mount 16. The
20 radiation emitter 18, 20 each have a first axis 32, 34. Radiation is emitted from the radiation emitters 18, 20 along their respective axes 32, 34 towards and through the transparent window 24 until it contacts the reflective material 12. The radiation detector 22 is mounted in the sensor mount 16 and adjacent and between the radiation emitters 18, 20. The radiation detector 22
25 is located to receive the radiation that is reflected back from the reflective material 12 located on the transparent window 24 along a second axis 36. The first axes 32, 34 of the radiation emitters 18, 20 are both angled towards the second axis 36. The two radiation emitters 18, 20 emit radiation towards a common focal point 38 on the upper surface 26 of the transparent window
30 24 and at a deviation from normal such that their radiation is not mirror reflected to the radiation detector 22 from the upper or lower transparent

window surfaces. The deviation from normal is also not large enough to cause all radiation to be reflected back into the housing 14. The radiation detector 22 is directed to the radiation emitter common focal point 38 on the upper surface of the transparent window.

- 5 Referring briefly to Figure 3, radiation emitters 18 and 20 and radiation detector 22 have overlapping fields of useful radiation and detection to sense precipitation over area 37.

Still referring to Figures 1A, 1B and 2, the sensor mount 16 includes two spaced apart cavities 40, 42 which are both aligned along their respective first
10 axes 32, 34 in which the radiation emitters 18, 20 are located. Another cavity 44 is aligned along the second axis 36 in which the radiation detector 22 is located.

As best illustrated in Figure 1B, the sensor mount 16 is located at a junction
45 between the housing wall 30 and a housing floor 46 so that sensor mount
15 16 is angled away from the housing wall 30.

Still referring to Figure 1B, a radiation baffle wall 48 extends into the housing 14 from the housing wall 30. The baffle wall 48 may be used to block external radiation sources such as the sun from the radiation detector 22. A temperature sensor 50 is located on the lower surface 28 of the transparent
20 window 24 out of the radiation detector's 22 field of view, which will not cause a false reflection to the sensor. The baffle wall 48 can be constructed of any suitable shape to define the boundaries to radiation window 52 through which both the radiation from the radiation emitters 18, 20 and the radiation reflected back from the reflective material 12 passes.

- 25 Each of the radiation emitters is a Light Emitting Diode (LED).

The radiation emitters 18, 20 are disposed so that radiation emitted through the transparent window 24 is at an angle that does not cause a surface reflection back to the radiation detector 22.

Referring now to Figure 1, Figure 2 and Figure 4, a controller 54, which is typically a microprocessor or equivalent device, communicates with a variable resister 56 or fixed resister 56A, the radiation detector 22, the radiation emitters 18, 20 and the temperature sensor 50 to achieve the reflective material sensing function. The controller 54 may be located within the housing 14, or in another suitable housing. One skilled in the art will understand that other devices and circuitry such as cabling, voltage supply, ground, signal buffering, user communication, controller programming, and the like may also be integrated into the sensing function.

10

Referring now to Figure 4, the radiation sensor 22 operates as an electrical current valve, which permits higher current flow at higher radiation levels. A radiation signal 58 is produced by passing a reference voltage 60 through the variable resister 56 and then the radiation detector. As radiation increases, the current flow through the radiation detector 22 increases, causing an increased voltage drop across the variable resister 56. To allow for a wide range of radiation, the controller 54 modifies the value of the variable resister 56 to produce a usable signal. For installations where the ambient radiation range is small, an inexpensive fixed resister 56A may be used, thereby eliminating the need for the controller 54 to modify the resister 56A value. Alternatively, more than one copy of a fixed but different value resister 56A and radiation sensor 22 may be used to broaden the sensed radiation range.

Referring now to Figures 1, 2 and 5, the radiation sensor 22 is an integrated circuit 62 which includes a sensor such as a photo diode, photo transistor or light dependent resister and a means to autonomously convert the sensor output to the controller 54 compatible input such as frequency pulses.

Still referring to Figure 4 or 5, the controller 54 activates one or both of the radiation emitters 18, 20 when required to achieve the sense function. To assist in distinguishing between winter and non-winter precipitation, the

controller 54 communicates with the temperature sensor 50 to determine whether winter precipitation is possible.

The sensor 10 functions in a wide range of ambient radiations, from direct
5 sunlight to nighttime. It can sense winter precipitation or cold precipitation on, for example, greenhouses, atriums, windows, freezer glass doors, skylights; on planes, helicopters, and motorized transportation including trucks, cars, motor bikes, recreational vehicles, trains, boats and the like; food services, freezers /fridges, spacecraft, buildings, photovoltaic solar (conventional
10 panels and non conventional solar applications), trough reflectors; for landscaping such as grass and garden maintenance, crops; or for weather determination, climate, ecosystem preservation; or for medical applications and storage of tissues and cells, sterilizations; or for food preparation and preservation, and the like. When operated in non-winter conditions, the sensor
15 10 may also detect dirt on these types of surfaces to support cleaning operations. With a durable transparent cover, it can also sense winter precipitation when installed in sidewalks, driveways, walkways, roads, roofs, infrastructure projects and the like. The sensor 10 can be used in solar applications for building materials such as decking, walls and shingles.

20 While the sensor 10 can be used to sense winter precipitation, it is easily applied to sensing other reflective materials such as, for example, liquids, precipitates, contamination, some gases, suspended solids, and the like, and as such can be applied to manufacturing and distribution processes for food,
25 chemicals, fuels, and the like.

Operation

Referring now to Figure 1 and Figure 4, operation of the sensor 10 will be described. Winter precipitation is sensed by determining the change in the
30 radiation signal 58 when the radiation emitters 18, 20 are "off" then "on". Firstly, the controller 54 determines if winter precipitation is possible by communicating with the temperature sensor 50. If winter precipitation is

possible, then the controller 54 determines a reference ambient radiation signal 58 by first not switching on the radiation emitters 18, 20, then modifying the variable resistor 56 until the radiation signal 58 is approximately 90% of the reference voltage 60. The controller 54 determines the reference ambient radiation by comparing the resultant variable resistor 56 resistance with internally stored data. If the fixed resistor 56A is used, the controller 54 determines reference ambient radiation by comparing the radiation signal 58 with internally stored data.

Referring now to Figure 5, an alternative operation of the sensor 10 will now be described. Winter precipitation is sensed by determining the change in the radiation signal 58 when the radiation emitters 18, 20 are "off" then "on". Firstly, the controller 54 determines if winter precipitation is possible by communicating with the temperature sensor 50. If winter precipitation is possible, then the controller 54 determines a reference ambient radiation signal by first not switching on the radiation emitters 18, 20 then communicating with the radiation detector 62.

Referring now to Figures 4 and 5, the controller 54 then turns on one or both of the radiation emitters, depending on the ambient radiation. At high ambient radiation, both radiation emitters 18, 20 may be required to obtain an adequate change in the radiation signal 58. The controller 54 then determines that winter precipitation is present if the radiation signal 58 value has changed from the reference ambient radiation signal value by more than the combined effect of impurities in the transparent window 24 and expected dirt on the transparent window 24. The controller 54 may also determine the type of winter precipitation based on the combination of the temperature sensor 50 and the radiation signal 58 change.

When used in non-winter precipitation mode to sense other materials, the temperature sensor 50 can be eliminated, or used to distinguish between

winter precipitation and non-winter reflective material such as accumulating grime.

Although the above description relates to a specific preferred embodiment as
5 presently contemplated by the inventor, it will be understood that the WPS in
its broad aspect includes mechanical and functional equivalents of the
elements described herein.

CLAIMS

We claim:

1. A sensor for sensing reflective material, the sensor comprising:
 - a housing having a transparent window;
 - a sensor mount located in the housing and angled away from a housing wall;
 - a radiation emitter mounted in the sensor mount for emitting radiation along a first axis through the transparent window, the transparent window having an amount of the reflective material located thereon; and
 - a radiation detector mounted in the sensor mount and located adjacent the radiation emitter, the radiation detector being located to receive reflected radiation from the reflective material along a second axis, the first axis being angled towards the second axis.
2. The sensor, according to claim 1, includes two radiation emitters each located on either side of the radiation detector, the two radiation emitters being mounted to emit radiation along their respective first axes through the transparent window towards a common focal point on an outer surface of the transparent window.
3. The sensor, according to claim 2, in which the sensor mount includes two spaced apart cavities aligned along the respective first axes in which the radiation emitters are located, and another cavity aligned along the second axis in which the radiation detector is located.
4. The sensor, according to claim 1, in which the sensor mount is located at a junction between the housing wall and a housing floor so that sensor mount is angled away from the housing wall.

5. The sensor, according to claim 1, in which a baffle extends into the housing from the housing wall.
6. The sensor, according to claim 1, in which a temperature sensor is located on a lower surface of the transparent window.
7. The sensor, according to claim 1, in which a baffle wall extends into the housing from the housing wall; and a temperature sensor is located on a lower surface of the transparent window.
8. The sensor, according to claim 1, in which the radiation emitter is a Light Emitting Diode (LED).
9. The sensor, according to claim 1, in which the radiation sensor is a photo transistor or photo diode located adjacent to the radiation emitter so as to detect reflected radiation.
10. The sensor, according to claim 1, in which the radiation emitter is disposed so that radiation is emitted through the transparent window at an angle that does not cause a surface reflection back to the radiation detector.
11. The sensor, according to claim 6, in which a controller is located in the housing and is connected to a variable resistor, the radiation detector, the radiation emitter and the temperature sensor.
12. The sensor, according to claim 6, in which a controller is located in the housing and is connected to a fixed resistor, the radiation detector, the radiation emitter and the temperature sensor.
13. The sensor, according to claim 1, in which the radiation detector is an integrated circuit having a photo transistor, a photo diode or a light dependent resistor located adjacent to the radiation emitter so as to detect reflected radiation.

14. The sensor, according to claim 1, in which the reflective material is winter precipitation.
15. The sensor, according to claim 14, in which the winter precipitation is snow, sleet, frost, ice or ice pellets.
16. The sensor, according to claim 1, in which the reflective material is non-winter precipitation.
17. The sensor, according to claim 16, in which the non-winter precipitation is reflective liquids, dirt, or particulate material suspended in liquids.
18. The sensor, according to claim 1, is mounted for use on motorized transportation including trucks, cars, motor bikes, recreational vehicles, trains, or boats
19. The sensor, according to claim 1, is mounted for use on solar panels and trough reflectors.
20. The sensor, according to claim 1, is mounted for use on sidewalks, driveways, walkways, roads, roofs, or infrastructure projects.
21. The sensor, according to claim 1, is mounted for use with greenhouses, atriums, windows, freezer glass doors, skylights; on planes, helicopters; food services, freezers /fridges, spacecraft, buildings; for landscaping such as grass and garden maintenance, crops; or for weather determination, climate, ecosystem preservation; or for medical applications and storage of tissues and cells, sterilizations; or for food preparation and preservation.
22. The sensor, according to claim 1, is used in solar applications for building materials including decking, walls or shingles.

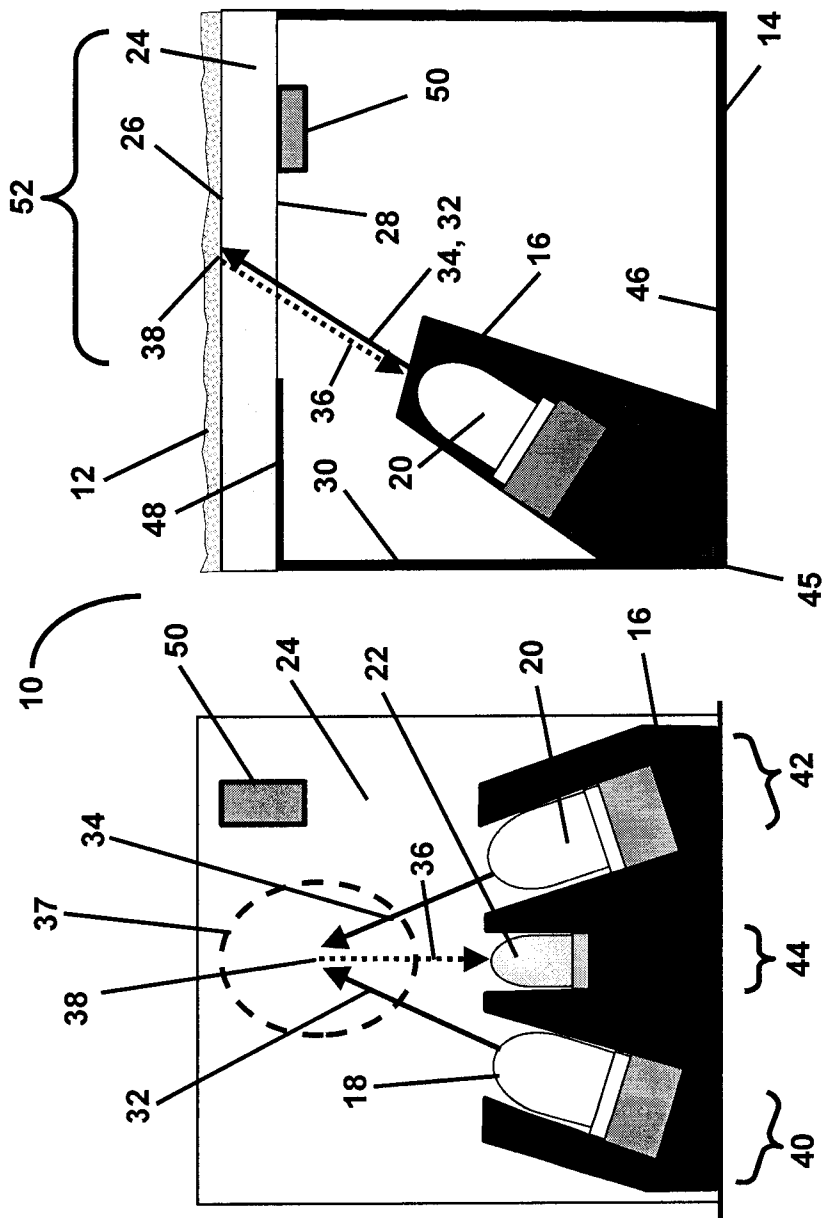


Figure 1B Side View

Figure 1A Top View

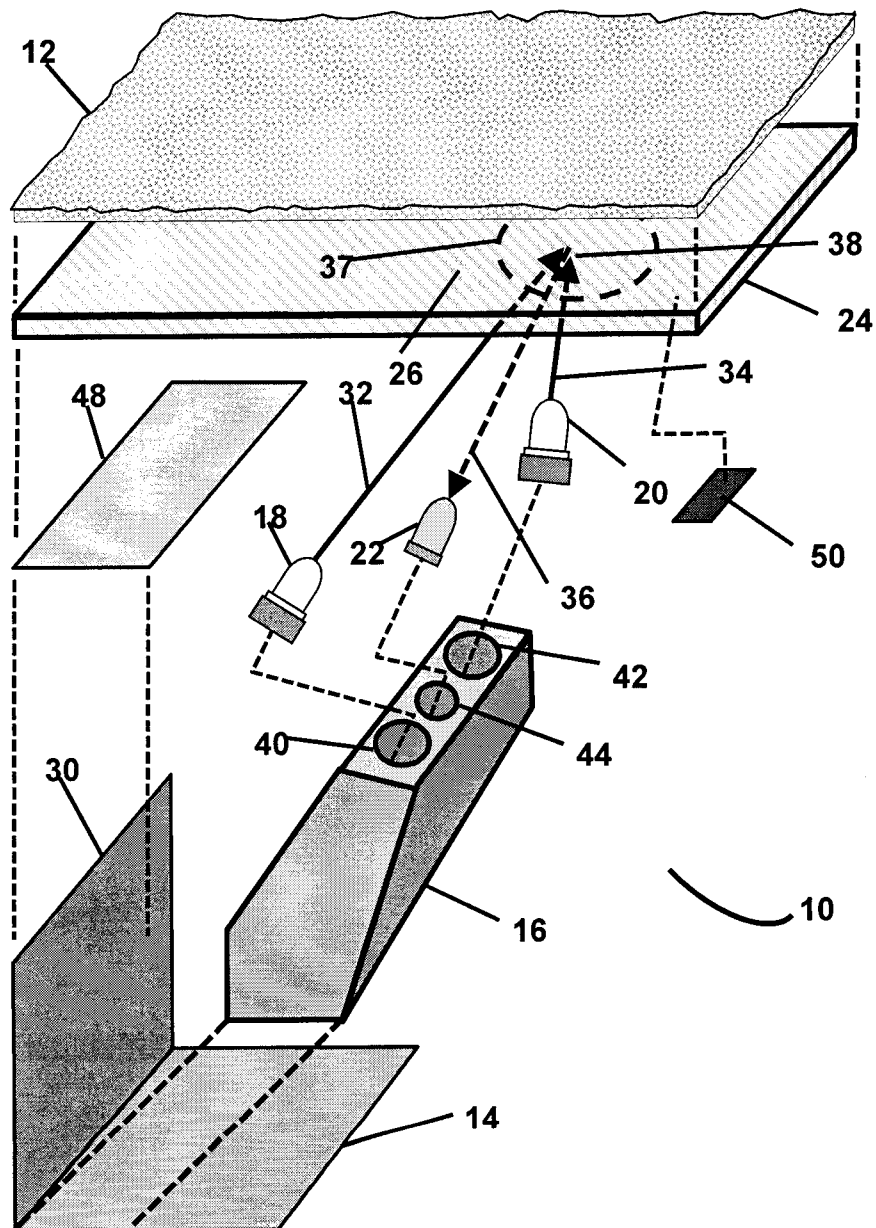


Figure 2

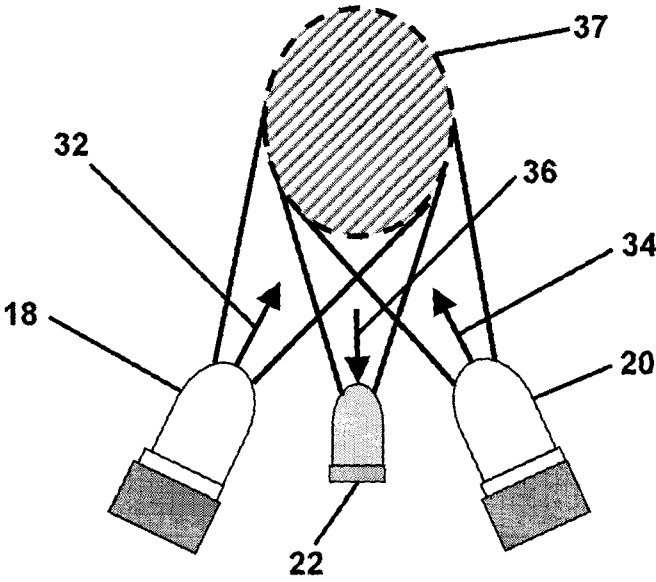
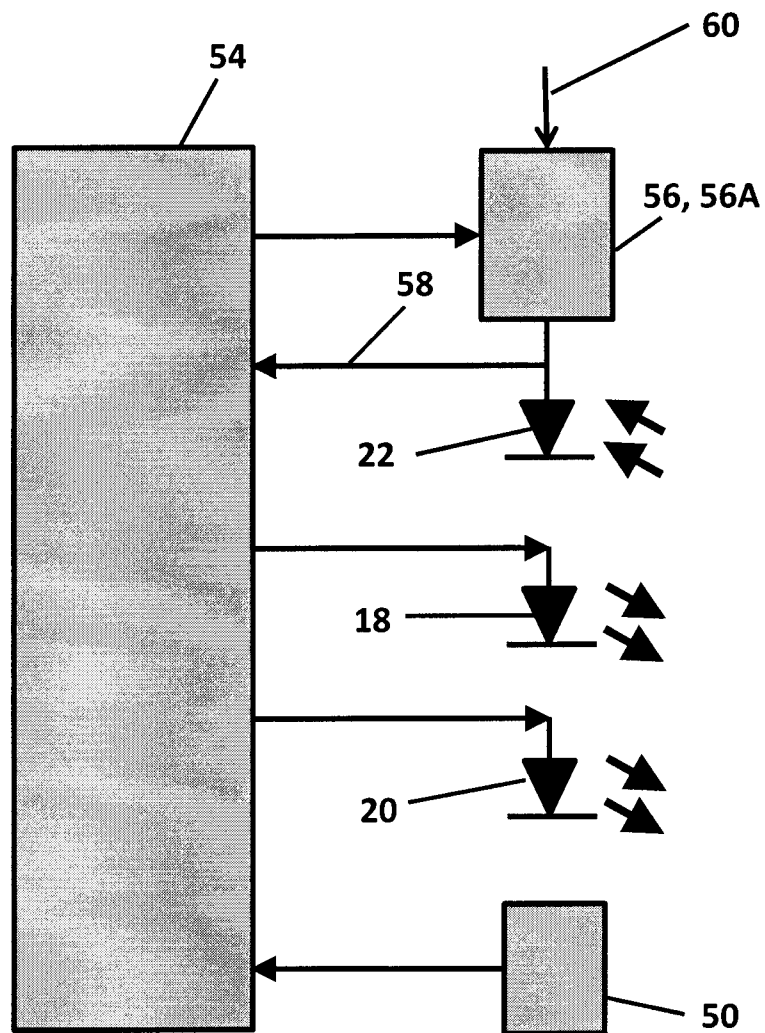


Figure 3

**Figure 4**

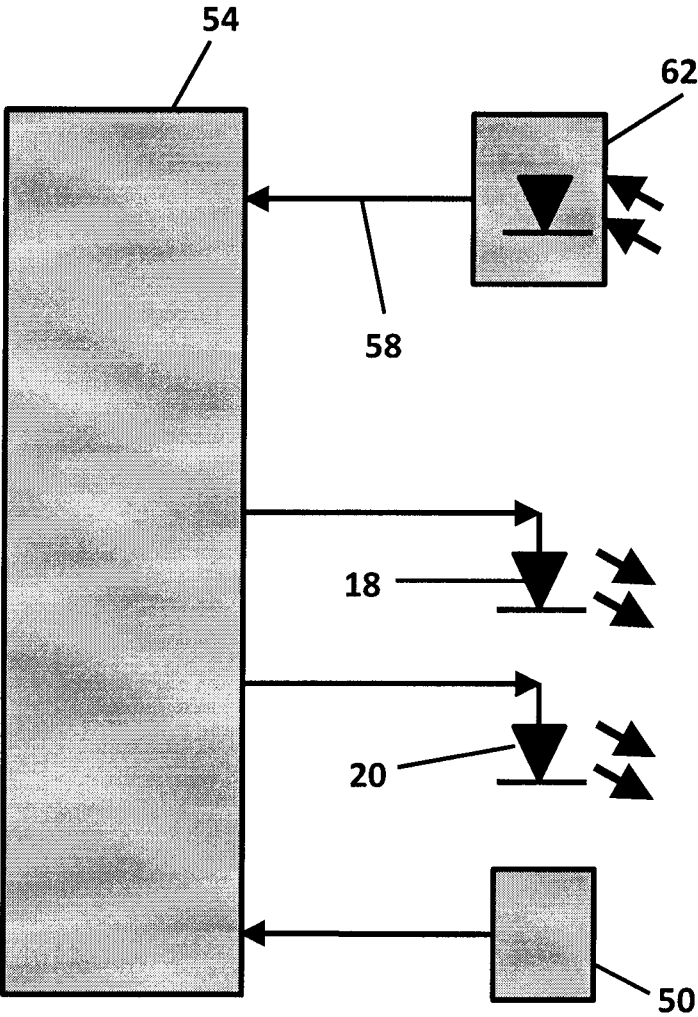


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2013/000698

A. CLASSIFICATION OF SUBJECT MATTER IPC: G01N 21/55 (2006.01) , B64D 15/20 (2006.01) , H01L 31/042 (2006.01) According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC(2006.01): G01N, B64D, H01L Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used) Epoque, Canadian Patent Database, IEEE Xplore (Keywords: detect/sens rain/fog/snow/precipitation; housing; window; sensor mount; radiation emitter; radiation detector)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6,376,824 B1 (MICHENFELDER et al.) 23 April 2002 (23-04-2002) * Whole document *	1-22
A	US 6,853,897 B2 (STAM et al.) 08 February 2005 (08-02-2005) * Whole document *	1-22
A	US 2006/0076478 A1 (JOHNSON et al.) 13 April 2006 (13-04-2006) * Whole document *	1-22
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	
"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	
"&"	document member of the same patent family	
Date of the actual completion of the international search 17 October 2013 (17-10-2013)		Date of mailing of the international search report 24 October 2013 (24-10-2013)
Name and mailing address of the ISA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476		Authorized officer Patrick Abou-Antoun (819) 994-7470

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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International application No.
PCT/CA2013/000698

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