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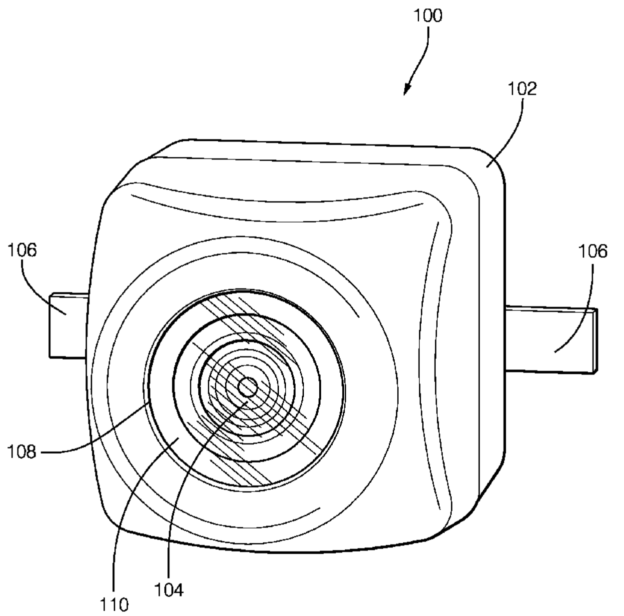

FIG. 1

(57) Abstract: A sensor assembly (100) configured for use in a motor vehicle is presented. The sensor assembly (100) includes a sensor device (104) such as a camera, LIDAR, RADAR, or ultrasonic transceiver, and a housing (102) that is at least partially formed of an electrically conductive polymeric material. The housing (102) has a pair of electrically conductive terminals (106) connected to the electrically conductive polymeric material. The pair of electrically conductive terminals (106) are configured to be interconnected with an electrical power supply. When the terminals (106) are connected to the power supply, the housing (102) heats to remove snow, ice, frost and/or condensation from the sensor assembly (100). The sensor assembly (100) is suitable for use with a back-up camera, blind spot warning system, lane departure warning system, adaptive cruise control system and/or autonomous driving control system.

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SENSOR ASSEMBLY WITH INTEGRAL DEFROSTER/DEFOGGER

TECHNICAL FIELD OF THE INVENTION

[0001] The invention generally relates to sensor assemblies, and more particularly relates to a sensor assembly with an integral defroster and/or defogger used in a motor vehicle.

BACKGROUND OF THE INVENTION

[0002] Sensors such as cameras, radio detection and ranging (RADAR), light detection and ranging (LIDAR), and ultrasonic sensors are used in today's vehicles to provide an input for safety related systems such as a back-up camera, blind spot warning, lane departure warning, and adaptive cruise control. These sensors are also key inputs for autonomous driving control systems. These sensors must be free of ice, snow, frost, and condensation in order to operate most effectively. Current sensors depend on their location inside the vehicle cabin to provide ice and snow removal due to windshield defroster and windshield wiper systems. However, not all sensors can be effectively packaged within the vehicle cabin. Those sensors depend on manual clearing by the vehicle operator prior to entering the vehicle. However, there is risk that the manual clearing could result in damage to the sensor. In addition, snow and ice may build up on the senor while the vehicle is driving, requiring the vehicle operator sot stop and again manually clear the sensor.

[0003] Therefore, a sensor that can be mounted outside of the vehicle cabin that is capable on removing ice, snow, frost, and/or condensation from the sensor remains desired.

[0004] The subject matter discussed in the background section should not be assumed to be prior art merely as a result of its mention in the background section. Similarly, a problem mentioned in the background section or associated with the subject matter of the background section should not be assumed to have been previously recognized in the prior art. The subject matter in the background section merely represents different approaches, which in and of themselves may also be inventions.

BRIEF SUMMARY OF THE INVENTION

[0005] In accordance with an embodiment of the invention, a sensor assembly configured for use in a motor vehicle is provided. The sensor assembly includes a sensor device and a housing at least partially formed of an electrically conductive polymeric material. The housing has a pair of electrically conductive terminals connected to the electrically conductive polymeric material. The pair of electrically conductive terminals are configured to be interconnected with an electrical power supply.

[0006] The walls of the housing may be formed of the electrically conductive polymeric material. The electrically conductive polymeric material may be a dielectric polymer material filled with conductive particles. The conductive particles may be carbon black particles, graphene particles, fullerene particles, carbon nanotubes, metallic particles, metallic fibers, and/or metal plated fiber particles.

[0007] The dielectric polymer material may be a highly crystalline polymer and the electrically conductive polymeric material may have a positive temperature coefficient (PTC) electrical resistance property.

[0008] The housing further may further include a transparent window and the sensor device may be an optical sensor device such as a visible light camera or light detection and ranging (LIDAR) transceiver. The transparent window may be formed of the electrically conductive polymeric material. The electrically conductive polymeric material may be a transparent polymer material filled with conductive particles such as metallic nanowires, metal-plated nanofibers, carbon nanotubes, graphene nanoparticles, and/or graphene oxide nanoparticles.

[0009] Alternatively, the sensor device may be a radio detection and ranging (RADAR) transceiver or an ultrasonic transceiver.

[0010] The electrically conductive polymeric material may include an inherently conductive polymer such as a conjugated polymer, radical polymer, and/or electro-active polymer.

[0011] The sensor assembly may further include a temperature sensing element. The sensor assembly may be disposed on the motor vehicle outside of a passenger compartment. The sensor assembly may be a component of an automated vehicle control system.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0012] The present invention will now be described, by way of example with reference to the accompanying drawings, in which:

[0013] Fig. 1 is a perspective view of a sensor assembly including an optical sensor and a housing according to a first embodiment;

[0014] Fig. 2 is a perspective view of a sensor assembly including a non-optical sensor and a housing according to a second embodiment; and

[0015] Fig. 3 is a perspective view of a sensor assembly including an optical sensor and a housing according to a third embodiment.

[0016] Reference numbers of similar elements in the various illustrated embodiments share the last two digits of their reference numbers.

DETAILED DESCRIPTION OF THE INVENTION

[0017] A sensor assembly, such as those used in a motor vehicle for blind spot detection, automated parking assist, lane keeping, back-up monitors, and/or automated vehicle control, is described herein. The sensor assembly has a housing that is formed of a conductive plastic material. When an electrical current is applied to the housing, the electrical resistance of the conductive plastic material causes heating of the housing that can melt snow and ice or remove frost or condensation (fogging) on the housing, thereby reducing or eliminating any degradation of the senor function that may be caused by these conditions. The housing does not need any additional heating circuits, e.g. resistive wires, to heat the housing to remove snow, ice, frost, or condensation from the housing, generically referred to hereafter as defrosting. Such a housing is well suited for placement on the motor vehicle outside of the cabin since it does not need to rely on any other vehicle systems, such as window defrosters.

[0018] Fig. 1 illustrates a non-limiting example of a sensor assembly 100. The sensor assembly 100 includes a housing 102 formed of an electrically conducive plastic and a sensor device 104 contained within the housing 102. The housing 102 includes two terminals 106 that are connected to an electrical power supply (not shown). The housing 102 is formed of a thermoplastic material such as polycarbonate (PC), polyamide (nylon), polypropylene (PP), acrylonitrile butadiene styrene (ABS), polybutylene terephthalate PBT, or a combination of these materials that is filled with conductive particles such as carbon black particles, graphene particles, fullerene particles, carbon nanotubes, metallic particles, metallic fibers, and metal plated fiber particles to provide electrical conductivity to the material. Alternatively, the housing 102 may be formed of an inherently conductive polymer. Examples of inherently conductive polymers include conjugated polymers, radical polymers, and electro-active polymers

[0019] The terminals 106 may be threaded metal bushings or metal tabs that are insert molded into the housing 102 and are configured to be connected to wires leading to the electrical power supply.

[0020] Without subscribing to any particular theory of operation, when electrical current flows from the first terminal 106 to the second terminal 106, the electrical resistance of the material forming the housing 102 causes the temperature of the housing

102 to increase. The electrical current supplied to the housing 102 is preferably regulated to increase the surface temperature of the housing 102 above 0°C to melt any show or ice on the housing 102 or alternatively increase the surface temperature above the dew point to remove any condensation from the housing 102 while keeping the temperature below the softening or melting point of the electrically conducive plastic forming the housing 102. The electrical current supplied to the terminals 106 is preferably direct (non-alternating) current.

[0021] Regulation of the current may be provided by a feedback circuit (not shown) that includes a temperature sensor, such as a thermistor, embedded within the sensor assembly 100 to a controller (not shown). This temperature sensor could also be used by the controller to determine the temperature of the sensor assembly 100 and active the power supply to send current to the terminals 106 when the temperature of the sensor assembly 100 is determined to be below freezing or dew point temperatures.

[0022] Alternatively or additionally, the electrical current provided form the power supply to the housing 102 may be regulated by using an electrically conductive plastic material to form the housing 102 that has a positive temperature coefficient (PTC) property, that is the electrically conductive plastic material has the property of increased electrical resistance as the temperature of the electrically conductive plastic material increases. Electrically conductive plastic materials having a highly crystalline polymer base material, such as polypropylene and nylon, exhibit this PTC property.

[0023] The PTC property of the electrically conductive plastic material relates to the temperature at which the material makes a change from a phase that is electrically conductive to a phase that is electrically nonconductive. Again, without subscribing to any particular theory of operation, the electrically conductive plastic material maintains its crystalline structure up to a certain phase change temperature, in most cases around 60°C, when it changes to an amorphous structure. This temperature is slightly lower than the electrically conductive plastic material's melting point, preferably low enough for the material to maintain its structural integrity. When below the phase change temperature, the conductive particles are inherently connected to form conductive pathways through the material. As the material approaches the phase change temperature, these conductive particles that were connected in the crystalline phase are disconnected from one another and "float" within the amorphous phase of the material. The housing 102 ceases to increase in temperature and maintains a fairly constant temperature since the current flowing though the material is greatly decreased.

[0024] Upon cooling below the phase change temperature, the electrically conductive plastic material reverts to its previous crystalline structure whereby the conductive particles reconnect, but not necessarily in the exact same configuration as before. Since the conductive particles do not reconnect in exactly the same way, the electrically conductive plastic material may become more resistive the second time it is brought to its phase change temperature. The electrically conductive plastic material may continue to become more resistive for about three or four more cycles to the phase change temperature until the resistance stabilizes and will remain consistent for thousands, perhaps hundreds of thousands of cycles.

[0025] The sensor device 104 may be a visible light camera, RADAR transceiver, LIDAR transceiver, or ultrasonic transceiver. As used herein, a visible light camera refers to a camera that is sensitive to wavelengths in the range of 400 to 1000 nanometers. The housing 102 defines an opening 108 through which the sensor can observe the surrounding environment since light waves used by a camera or LIDAR receiver, sound waves used by an ultrasonic transceiver, and radio waves used by a RADAR transceiver may be attenuated or blocked by the electrically conductive plastic material forming the housing 102. The opening 108 of a housing 102 used with a LIDAR transceiver or camera may be covered by a transparent plastic material forming a window 110 as shown in Fig. 1. The opening of a housing 102 used with a RADAR transceiver or ultrasonic transceiver may be covered by a nonconductive opaque plastic material 210 as illustrated in Fig. 2.

[0026] Fig. 3 illustrates another non-limiting example of a sensor assembly 300 similar to that shown in Fig. 1. However, the housing 302 of this sensor assembly 300 is formed of a nonconductive plastic and the transparent plastic material of the window 310 is formed of a transparent conductive plastic material such as a polycarbonate that contains nano-scale conductive particles such as metallic nanowires, metal-plated nanofibers, carbon nanotubes, graphene nanoparticles, or graphene oxide nanoparticles. As used herein, nano-scale particles have a size between 1 and 100 nanometers. The electrically conductive plastic window 310 is connected to the terminals 306 by wires or conductive traces 312, preferably disposed within the housing 102. This sensor assembly 200 provides the benefit of heating only the window needed by the camera or LIDAR transceiver rather than the entire housing 302, thereby reducing the electrical power required for defrosting the sensor assembly 300.

[0027] Other embodiments may be envisioned in which the window 310 formed of transparent conductive plastic material of Fig. 3 is incorporated into the housing 102 formed of an electrically conductive material of Fig. 1, wherein the window 310 is connected to the terminals 106 thought the housing 102 rather than separate conductors. Yet other alternative embodiments may be envisioned in which the material covering the opening 208 in Fig. 2 is formed of an electrically conductive plastic material filled with nano-scale conductive particles and is incorporated in the nonconductive plastic housing 302 of Fig. 3.

[0028] Accordingly, a sensor assembly is provided. The sensor assembly provides the benefit of electrically controlled defrosting capability, i.e. an integral defroster, without additional discrete heating elements, thereby reducing part count and assembly labor time.

[0029] While this invention has been described in terms of the preferred embodiments thereof, it is not intended to be so limited, but rather only to the extent set forth in the claims that follow. Moreover, the use of the terms first, second, etc. does not denote any order of importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items. Additionally, directional terms such as upper, lower, etc. do not denote any particular orientation, but rather the terms upper, lower, etc. are used to distinguish one element from another and locational establish a relationship between the various elements.

WE CLAIM:

1. A sensor assembly (100) configured for use in a motor vehicle, comprising:

a sensor device (104); and

a housing (102) at least partially formed of an electrically conductive polymeric material, said housing (102) having a pair of electrically conductive terminals (106) connected to the electrically conductive polymeric material, said pair of electrically conductive terminals (106) being configured for interconnection with an electrical power supply.

2. The sensor assembly (100) according to claim 1, wherein walls of the housing (102) are formed of the electrically conductive polymeric material.

3. The sensor assembly (100) according to claim 2, wherein the electrically conductive polymeric material is a dielectric polymer material filled with conductive particles.

4. The sensor assembly (100) according to claim 3, wherein the conductive particles are selected from a group consisting of: carbon black particles, graphene particles, fullerene particles, carbon nanotubes, metallic particles, metallic fibers, and metal plated fiber particles.

5. The sensor assembly (100) according to claim 3, wherein the dielectric polymer material is a highly crystalline polymer and wherein the electrically conductive polymeric material has a positive temperature coefficient (PTC) electrical resistance property.

6. The sensor assembly (100) according to claim 1, wherein the housing (102) further comprises a transparent window (110) and wherein the sensor device (104) is an optical sensor device (104).

7. The sensor assembly (100) according to claim 6, wherein the transparent window (110) comprises the electrically conductive polymeric material.

8. The sensor assembly (100) according to claim 7, wherein the electrically conductive polymeric material is a transparent polymer material filled with conductive particles.

9. The sensor assembly (100) according to claim 8, wherein the conductive particles are selected from a group consisting of: metallic nanowires, metal-plated nanofibers, carbon nanotubes, graphene nanoparticles, and graphene oxide nanoparticles.

10. The sensor assembly (100) according to claim 6, wherein the optical sensor device (104) is selected from a group consisting of visible light camera and light detection and ranging (LIDAR) transceivers.

11. The sensor assembly (100) according to claim 1, wherein the sensor device (104) is selected from a group consisting of radio detection and ranging (RADAR) transceivers and ultrasonic transceivers.

12. The sensor assembly (100) according to claim 1, wherein the electrically conductive polymeric material includes an inherently conductive polymer selected from a group consisting of conjugated polymers, radical polymers, and electro-active polymers.

13. The sensor assembly (100) according to claim 1, wherein the sensor assembly (100) further comprises a temperature sensing element.

14. The sensor assembly (100) according to claim 1, wherein the sensor assembly (100) is disposed on the motor vehicle outside of a passenger compartment.

15. The sensor assembly (100) according to claim 14, wherein the sensor assembly (100) is a component of an automated vehicle control system.

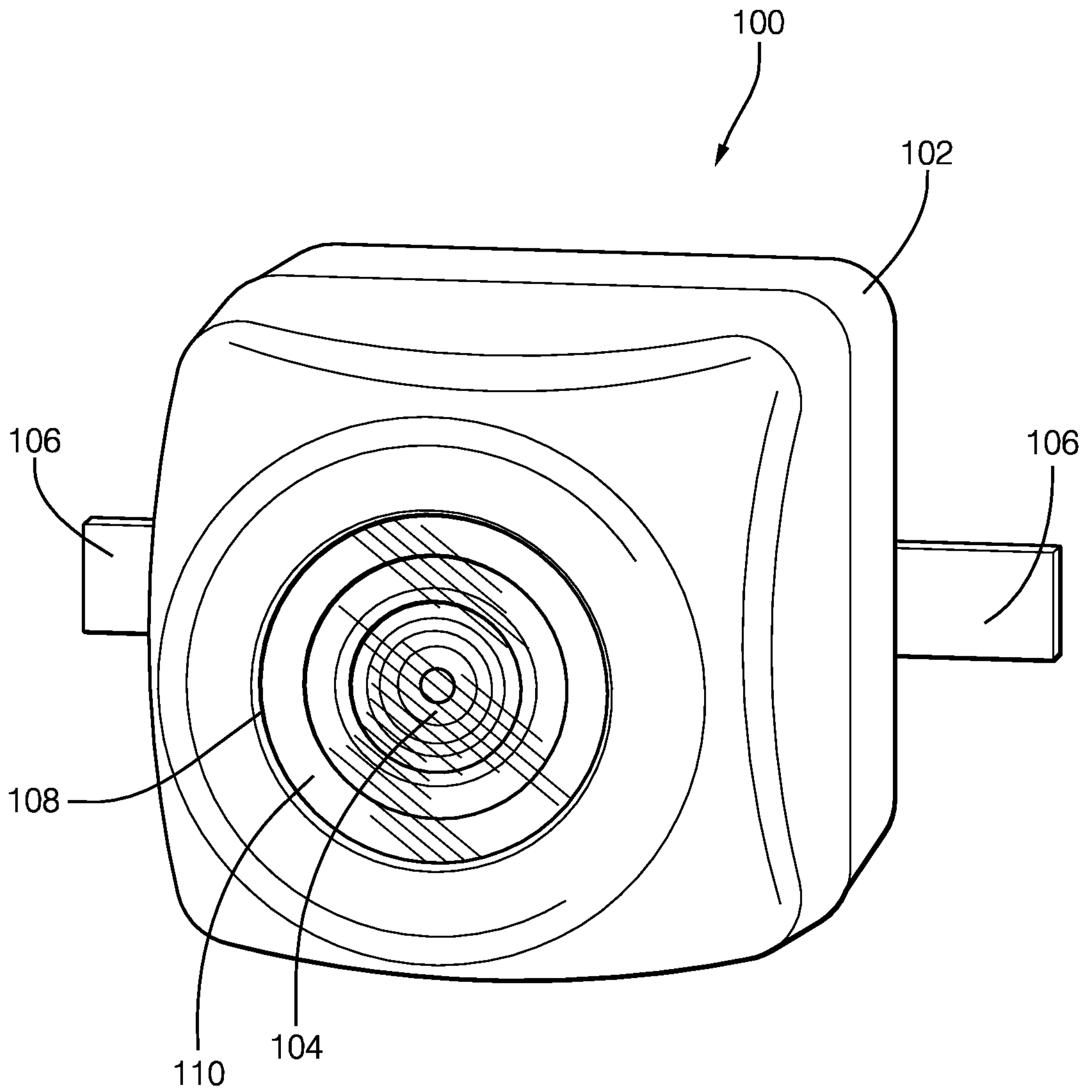

FIG. 1

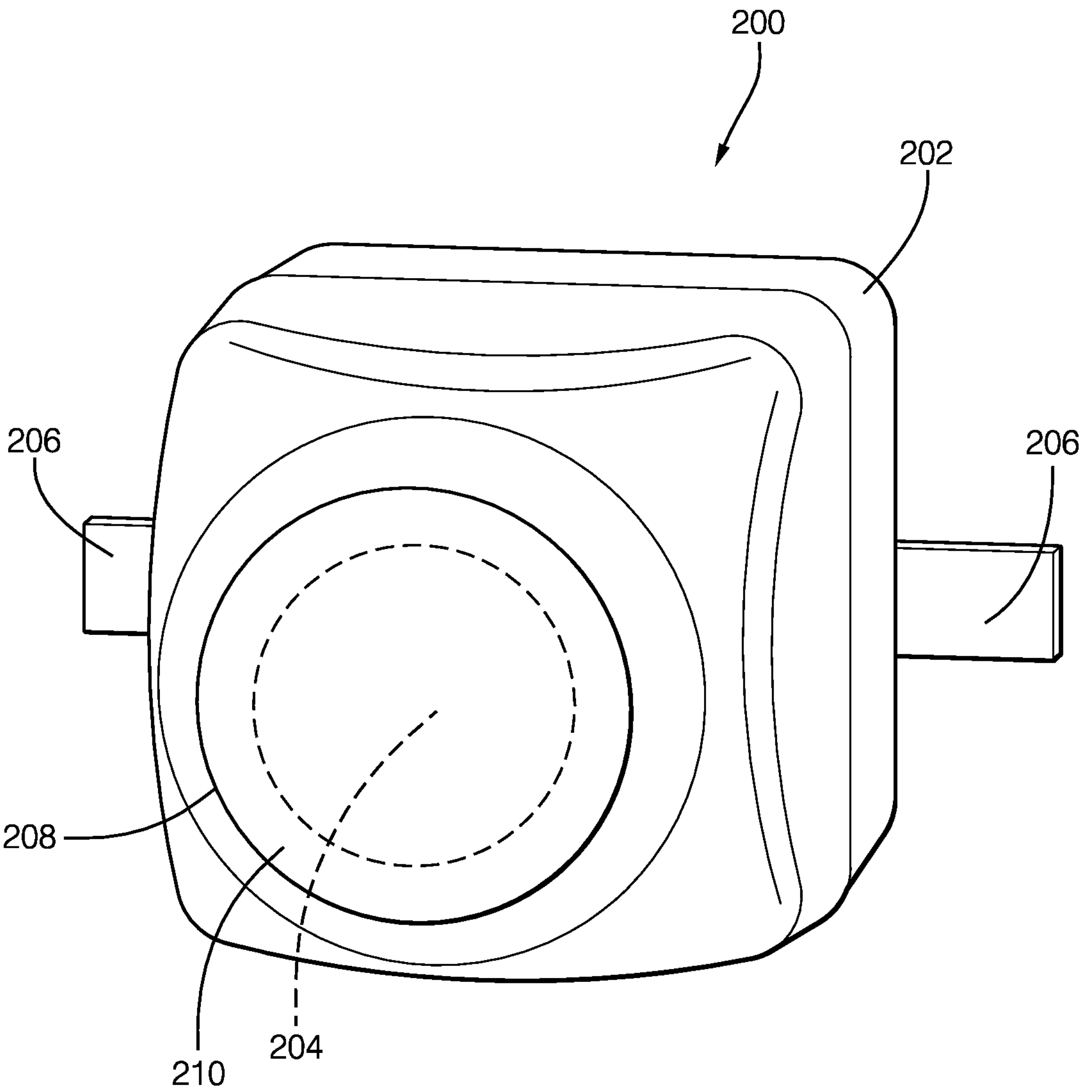

FIG. 2

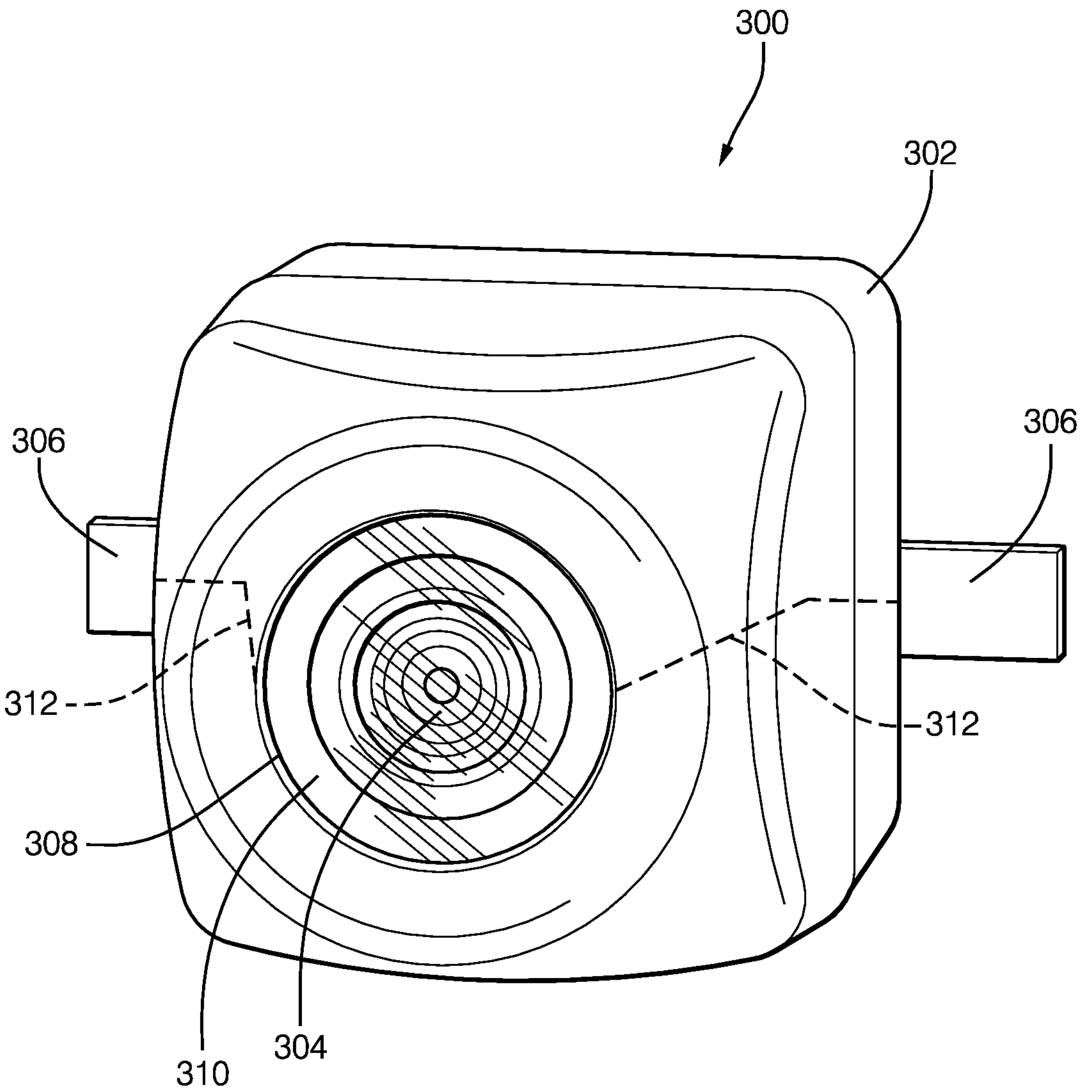

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/021443

A. CLASSIFICATION OF SUBJECT MATTER

G01S 7/481(2006.01)i, G01S 17/89(2006.01)i

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)
G01S 7/481; G03B 17/56; B60R 1/00; B60J 1/00; B60R 11/04; H04N 5/225; G06F 19/00; B60H 1/00; H05B 3/86; B08B 3/04; G08B 13/24; G01S 17/89

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: optical sensor, vehicle, defrost, terminal, housing

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 2005-0046569 A1 (TIMOTHY JOHN SPRIGGS et al.) 03 March 2005 See paragraphs [0036]-[0048] and claim 23.	11,15
A	US 2013-0146577 A1 (CONTINENTAL AUTOMOTIVE SYSTEMS, INC.) 13 June 2013 See paragraphs [0021]-[0026] and claim 1.	1-15
A	JP 2012-037548 A (DENSO CORP.) 23 February 2012 See figure 1 and claim 1.	1-15
A	US 2014-0124495 A1 (BEIJING FUNATE INNOVATION TECHNOLOGY CO., LTD.) 08 May 2014 See paragraphs [0019]-[0023] and claim 18.	1-15

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"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	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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