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(54) **INFRARED SAFETY SYSTEM TO IMPROVE THE VISIBILITY OF OBJECTS AND INFRARED SAFETY REFLECTIVE ELEMENT**

(57) The essence of the invention in that it contains an infrared thermographic camera and at least one safety reflective element, located on an object whose visibility is ensured, while the functional optical surface of the safety reflective element is located in the field of view of the infrared thermographic camera and the infrared thermographic camera is located in the field of reflection of the sky from the functional optical surface of the safety reflective element.

The subject of the invention is also an infrared safety reflective element, the essence of which is that the functional optical surface of the safety reflective element has a spectral reflectance in the band 1 to 15 μm higher than 0.5, while the area of the functional optical surface is greater than 25 mm^2.

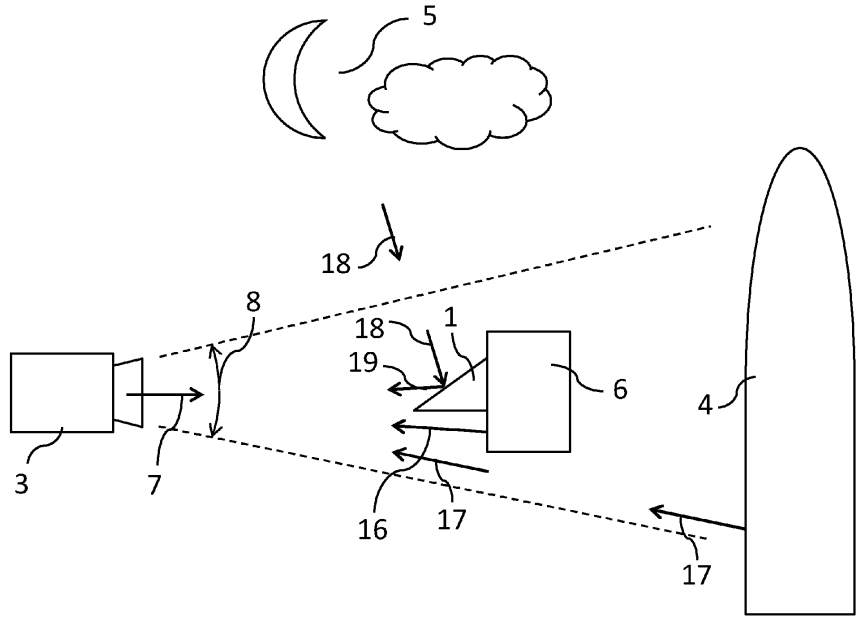

FIG. 1

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Description

Field of technology

[0001] The invention relates to an infrared security system that ensures an increase in the visibility of objects when it is desirable to ensure maximum visibility from a security point of view, and when the natural visibility of the object with the human eye or a video camera is not sufficient to distinguish the object from its surroundings. The invention further relates to an infrared safety reflective element. Typically, these are requirements for ensuring traffic safety in the operation of autonomous or human-controlled means of transport, participants in traffic or transport infrastructure.

Current state of the art

[0002] Infrared thermographic cameras are used in vehicles to increase the visibility of surrounding objects as a driver assistance system or as part of autonomous vehicle sensors. The reason is that the human eye or a video camera under reduced visibility conditions, such as darkness or fog, are not able to sufficiently distinguish surrounding objects, especially other means of transport, participants in traffic, traffic infrastructure, and thus there is an increased risk of a traffic accident. A similar effect is achieved by the use of lights that illuminate the surroundings of the vehicle in the visible range for the driver, but reduce the visibility of the surroundings for drivers of oncoming vehicles. The imaging of objects by an infrared thermographic camera is not affected by the aforementioned light problems that is why infrared thermographic cameras are used as driver assistance systems or as part of the sensors of autonomous vehicles.

[0003] Within the current state of the art, the use of infrared thermographic cameras in transport is limited to cases where the object's surface has a different temperature from its surroundings. The disadvantage is that the detection of objects is based only on the natural processes of thermal radiation of objects, and in certain cases the objects are not sufficiently distinguishable against the background of their surroundings in the infrared radiation band. On the one hand, these are cases where an object, for example a covered pedestrian in winter clothes at low temperatures, approaches its surroundings with its thermal footprint. On the other hand, there are cases when a part of the surroundings with its thermal footprint is close to objects of traffic, for example, in summer, tree trunks heated by sunlight look similar to pedestrians in light summer clothes when viewed by an infrared thermographic camera.

[0004] Safety reflective elements are widely used to increase visibility. They can be found on the clothing of traffic participants, on vehicles and on the transport infrastructure. These reflective elements are based on the principle of retroreflectivity. They reflect visible light that comes from a light source in the direction of an observer who is connected to this source of illumination. Typically, this involves using the main or dipped beam of a moving car and reflecting it with the help of reflective elements, for example on bollards around the road, towards the driver of this car.

[0005] As part of the current state of the art, safety reflective elements are used for the visible range of electromagnetic radiation. The disadvantages of these retroreflective elements are, on the one hand, the need for a source of radiation that must illuminate this safety reflective element, otherwise it cannot be seen, and, on the other hand, the fact that these reflective elements are designed to reflect the visible part of the spectrum of electromagnetic radiation and do not fulfil this function of retroreflectivity for infrared radiation.

[0006] To increase visibility, active sources of radiation are also used, for example safety lights alerting the driver to construction work in progress and related obstacles on the road or beacons of different colours alerting the driver to moving or standing transport or rescue vehicles.

[0007] The disadvantage of these safety lights is that they consume energy and it is necessary to ensure their power either through batteries or by connecting to the electrical network. Another disadvantage is that they primarily emit light, i.e. the visible part of the spectrum of electromagnetic radiation. They are thus rather invisible to infrared thermographic cameras and blend in with their surroundings.

The essence of the invention

[0008] The mentioned disadvantages are largely eliminated by the infrared safety system for improving the visibility of objects according to the invention, the essence of which is that it contains an infrared thermographic camera and at least one safety reflective element, placed on the object whose visibility is ensured, while the functional optical surface of the safety reflective element is located in the field of view of the infrared thermographic camera, and the infrared thermographic camera is located in the field of reflection of the sky from the functional optical surface of the safety reflective element.

[0009] A moving aperture is advantageously inserted between the functional optical surface of the safety reflective element and the infrared thermographic camera.

[0010] The subject of the invention is also an infrared safety reflective element, the essence of which is that the functional optical surface of the safety reflective element has a spectral reflectance in the band 1 to 15 μm higher than 0.5, while the area of the functional optical surface is greater than 25 mm^2.

[0011] The functional optical surface of the safety reflective element is preferably made up of at least two parts, each of which is oriented differently in the vertical and/or horizontal direction. , whereby the safety reflective element may include a rotating mechanism.

[0012] The safety reflective element preferably has the shape of a truncated cone or a truncated pyramid.

[0013] The functional optical surface of the safety reflective element can be applied directly to the surface of the object whose visibility is ensured and copies its shape.

[0014] The basic advantage of the infrared security system and the infrared security reflective element according to the invention is that they purposefully increase the visibility of the object using infrared thermographic cameras, beyond the normal state given by the natural temperature distribution of the object and its background.

[0015] Since the infrared radiation of the sky is significantly lower than the infrared radiation of objects and their surroundings, in the entire natural range of summer and winter temperatures day and night, the infrared safety reflective elements according to the invention provide sufficient contrast to distinguish the object from its background in a much wider spectrum of traffic situations, and thus enable a much more effective use of infrared thermographic cameras to ensure safety, for example in traffic.

[0016] Another advantage of the infrared security system, including the infrared security reflective element according to the invention, is that by using a greater number of these elements on an object, its characteristic shape can be visualized. By using parts of the element that affect the processes of infrared radiation, temporal changes in visibility for an infrared thermographic camera can be provided. The benefit is a further increase in the information value of the use of these elements, which can, for example, better visualize dangers or direct the response of the driver or the control system of an autonomous vehicle.

[0017] The advantage of the infrared safety system, including the infrared safety reflective element according to the invention, is that they use an infrared region of the spectrum that is different from the use of retroreflective elements in the visible region of the spectrum, and therefore do not interfere with their function in any way. Since the infrared safety reflective element according to the invention works on a passive principle using the reflection of sky radiation, it does not require a radiation source for its function and thus eliminates the use of light sources and energy consumption for their operation.

Clarification of drawings

[0018] An exemplary embodiment of the invention is shown in the attached figures, where Fig. 1 schematically shows the overall arrangement of the infrared security system including infrared radiant processes and the principle of the function of the infrared safety reflective element, Fig. 2 shows a detail of the infrared safety reflective element and its functional parts, Fig. 3 shows an infrared safety reflective element with a functional optical surface consisting of multiple parts, Fig. 4 shows an infrared safety reflective element with a movable diaphragm, Fig. 5 shows an infrared safety reflective element with a rotating diaphragm, Fig. 6 shows a flip-up infrared safety reflective element, Fig. 7 shows rotatable infrared safety reflective element in plan view, Fig. 8 shows the rotatable infrared safety reflective element in side view, Fig. 9 shows the use of infrared reflective elements for the cases of infrared thermographic cameras on vehicles, Fig. 10 shows the use of the infrared safety reflective elements for the cases infrared thermographic cameras on the transport infrastructure.

Exemplary embodiment of the invention

[0019] An exemplary embodiment of the infrared safety reflective element 1 according to the invention is shown in Fig. 1, which shows the overall arrangement of the radiation processes and the principle of the function of the infrared safety reflective element **1.** The safety reflective element **1 is** placed on the object **6,** that has to be visible against the background when viewed by the infrared thermographic camera **3.** The safety reflective element **1 is** placed on the object **6** in such a way that it reflects the infrared radiation of the sky **18** into the assumed field of view **8** of the infrared thermographic camera **3** in its direction of view **7.** The infrared radiation of the object **16** and the infrared radiation of the background 17 and especially the reflected infrared radiation of the sky 19 are thus simultaneously present in the field of view 8 and fall on the detector of the infrared thermographic camera **3.**

[0020] A detail of the infrared safety reflective element **1** and its functional part is shown in Fig. 2. The body **13** forms the volume of the safety reflective element **1.** Attached to it is the attachment **15,** which is used to mount the safety reflective element **1** to the object **6.** Part of the surface of the body **13** forms a functional optical surface **2,** which has a high reflectivity in the infrared band of electromagnetic radiation, especially in the band of commonly used infrared thermographic cameras, i.e. between 1 and 15 micro meters. Volumetric metal materials such as copper or aluminium or their alloys can be used, or the functional optical surface **2** can be formed by depositing a thin layer of titanium nitride, for example.

[0021] The functional optical surface **2** is further characterized by the size of its surface and its spatial orientation. The minimum size of the functional optical surface **2** is 25 mm^2. This dimension is based on the requirement that the functional optical surface 2 occupies at least 3x3 pixels of the detector of the infrared thermographic camera **3** in the field of view **8** of the infrared thermographic camera **3** at the assumed viewing distance of the object **6.**

[0022] The spatial orientation of the functional optical surface **2** with respect to the infrared thermographic camera 3 and the sky 18 is such that the infrared thermographic camera 3 is located in the reflection field 10 of the sky 5**.** At the same time, this reflection field 10 of the sky **5** is defined by surrounding objects, for example trees, buildings, which prevent the infrared radiation of the sky **18** from impacting on the functional optical surface **2.**

[0023] The functional optical surface **2** of the safety reflective surface **1** can alternatively be made up of several parts oriented vertically or horizontally in different directions, as shown in Fig. 3. The shape of the body **13** and the individual parts of the functional optical surface **2** are oriented in such a way that they do not shade each other in the reflection of infrared sky radiation **18** to the assumed direction of view **7** of the infrared thermographic camera **3.** This arrangement is advantageously used in cases where it is necessary to reduce the platform area of the safety reflective element 1 or it is necessary to increase the field of reflection 10 of the sky **5.** With regard to the expected long-term use of the safety reflective element **1** in the external environment, it is advisable to equip the functional optical surface **2** with a protective cover 14. This protective cover 14 copies the shape of the functional optical surface **2** so that water runs off it when it rains. For example, it is made of polyethylene, i.e. a material with sufficient optical transmittance for the incident infrared radiation of the sky 18 and the reflected infrared radiation of the sky **19.**

[0024] To highlight the contrast of the reflected infrared radiation of the sky **18** and the infrared radiation of the object **16,** the construction of the safety reflective element **1** can be equipped with a movable aperture **11.** This movable aperture **11,** as shown in Fig. 4, in one of its positions prevents the reflected infrared radiation of the sky 18 from shining into the field of view **8** of the infrared thermographic camera **3.** In this position, the infrared thermographic camera **3** thus detects the infrared radiation of the object **16,** which comes from this movable aperture **11.** This construction of the safety reflective element **1** can be used in cases where it is necessary to make this safety reflective element **1** invisible at certain times. Either these are cases where, for a certain time, there is no need to make the object **6** visible for viewing by the infrared thermographic camera **3** and it is not advantageous to remove the safety reflective element **1** from the object **6,** or these are cases where the temporal change of the radiation falling on the infrared thermographic camera 3 will bring additional visibility of the object **6.** According to the requirements for the operation of the safety reflective element **1,** this movable aperture **11** can be realized by a manual or automatic mechanism.

[0025] Another way of realizing the safety reflective element **1** with a movable aperture **11** is shown in Fig. 5. It is a rotating movable aperture 11 with openings through which the reflected infrared radiation of the sky 19 passes into the infrared thermographic camera **3.** In the rotated position, the rotating movable aperture **11** covers the field of reflection 10 of the sky **5** and the infrared radiation of the object 16 comes into the infrared thermographic camera **3.** The rotational movement of the movable aperture **11** thus induces a periodic signal formed partly by the reflected infrared radiation of the sky 19 and partly by the infrared radiation of the object 16.

[0026] Another way to technically ensure a change in incidence of the reflected infrared radiation of the sky **18** on incidence of the infrared radiation of the object 16 on the infrared thermographic camera **3** is shown by the design of the safety reflective element **1** with a rotating mechanism 12 in Fig. 6. The rotating mechanism 12 enables a change in the spatial orientation of the body **13** and thus a change in the spatial orientation of the functional optical surface **2** to a position where the functional optical surface **2** does not reflect the infrared radiation of the sky **18** but the infrared radiation of the background 17 in the direction of view **7** of the infrared thermographic camera **3.** The background infrared radiation 17 is similar in intensity to the infrared radiation of the object 16 and different from the intensity of the reflected infrared radiation of the sky **19.** If the rotary mechanism 12 changes the spatial orientation of the body **13** and therefore changes the spatial orientation of the functional optical surface **2** outside the field of view **8** of the infrared thermographic camera **3,** for example by shading the security reflective element **1** with its own body **13,** the object **6** appears as if it were a functional optical surface **2** shaded by a moving aperture **11.**

[0027] The rotary mechanism 12 can also be used in the construction of the safety reflective element **1** in the arrangement shown in the platform view in Fig. 7 and in the side view in Fig. 8. The rotary mechanism 12 enables the spatial orientation of the body 13 and thus the functional optical surface **2** to be changed so that it periodically prevents the reflected infrared radiation of the sky **18** be incident in the direction of view **7** of the infrared thermographic camera **3.** Advantageously, in such a case, the design of the safety reflective element **1** is used with a functional optical surface **2** consisting of several parts that reflect the infrared radiation of the sky **18** in different directions. Infrared radiation of the object 16 and reflected infrared radiation of the sky 19 radiates cyclically at certain intervals on the detector of the infrared thermographic camera 3 directed in the direction of view **7** of the object **6** , to which such a rotating safety reflective element **1** is attached. The result is an enhancement of the visibility of the safety reflective element **1** and thus also of the object **6** with which the safety reflective element moves.

[0028] The use of infrared safety reflective elements according to the invention is such that the safety reflective element **1** is a part of the surface of a means of transport, transport infrastructure or a traffic participant and is used when sensing traffic with infrared thermographic cameras 3, which can be placed on means of transport or on transport infrastructure.

[0029] At times when its functional optical surface 2 is oriented in the direction of view 7 of the infrared thermographic camera 3 and the reflected infrared radiation of the sky 19 is not blocked by the movable aperture 11 or its body 13, a different radiation intensity falls on the detector of the infrared thermographic camera 3 from the surface of the functional optical surface 2 than from the surface of the object 6 on which the safety reflective element 1 is located, as well as from the background 4 of

the object 6. This difference in the spatial distribution of the intensity of the incident radiation and its time course ensures an increase in the visibility of the object 6 when scanned by the infrared thermographic camera 3.

[0030] An example of the use of infrared safety reflective elements 1 when scanning traffic with an infrared thermographic camera 3 placed as part of vehicles is shown in Fig. 9. The purpose is to display the traffic situation and draw attention to danger. The infrared safety reflective elements 1 fulfil their function if they are placed on non-moving parts of the transport infrastructure 22, such as on bollards, guardrails, building obstacles or as part of vertical or horizontal traffic markings. The infrared safety reflective elements 1 also fulfil their function if they are placed on moving means of transport 20, such as on cars and trucks, trams, trolleybuses or bicycles, or on traffic participants 21 as, for example, part of clothing or luggage of pedestrians.

[0031] An example of the use of infrared safety reflective elements 1 when sensing traffic with an infrared thermographic camera 3 placed as part of the traffic infrastructure 22. The purpose is to monitor traffic. The infrared safety reflective elements 1 fulfil their function if they are placed on moving means of transport 20, such as on cars and trucks, trams, trolleybuses or bicycles, or on traffic participants 21 as, for example, part of clothing or luggage of pedestrians.

Industrial applicability

[0032] The invention can be used in all situations in which it is necessary for security or other reasons to make the object visible beyond the scope of the object's visibility with the human eye. This involves the installation of safety reflective elements on parts of the means of transport, on traffic participants and on the transport infrastructure. The use is in combination with the use of infrared thermographic cameras installed as part of the vehicle as driver assistance systems or the sensor system of the autonomous vehicle. The use of an infrared security system to increase the visibility of objects is also possible in the case of the installation of stationary infrared thermographic cameras as part of the traffic infrastructure monitoring traffic, while safety reflective elements are placed on moving vehicles or traffic participants.

List of relationship tags

[0033]

1 - safety reflective element
2 - functional optical surface
3 - infrared thermographic camera
4 - background
5 - the sky
6 - object
7 - direction of view
8 - field of view
9 - direction of reflection
10 - field of reflection
11 - movable aperture
12 - rotating mechanism
13 - body
14 - protective cover
15 - attachment
16 - object infrared radiation
17 - background infrared radiation
18 - infrared radiation of the sky
19 - reflected infrared radiation of the sky
20 - means of transport
21 - traffic participant
22 - transport infrastructure

Claims

1. An infrared security system for improving the visibility of objects, **characterized by** the fact that it contains an infrared thermographic camera (3) and at least one security reflective element (1), located on the object (6), the visibility of which is ensured, while the functional optical surface (2) of the security of the reflective element (1) is located in the field of view (8) of the infrared thermographic camera (3) and the infrared thermographic camera (3) is located in the field of reflection (10) of the sky (5) from the functional optical surface (2) of the safety reflective element (1).

2. An infrared security system, according to claim 1, **characterized in that** a movable aperture (11) is inserted between the functional optical surface (2) of the security reflective element (1) and the infrared thermographic camera (3).

3. An infrared safety reflective element, according to claim 1, **characterized in that** the functional optical surface (2) of the safety reflective element (1) has a spectral reflectance in the band 1 to 15 μm higher than 0.5, while the area of the functional optical surface (2) is greater than 25 mm^2.

4. An infrared safety reflective element, according to claim 3, **characterized in that** the functional optical surface (2) of the safety reflective element (1) consists of at least two parts, each of which is oriented differently in the vertical and/or horizontal direction.

5. An infrared safety reflective element, according to one of the preceding claims, **characterized in that** the safety reflective element (1) contains a rotating mechanism (12).

6. An infrared safety reflective element, according to claim 5, **characterized in that** the safety reflective element (1) has the shape of a truncated cone or a

truncated pyramid.

7. An infrared safety reflective element, according to one of the preceding claims, **characterized in that** the functional optical surface (2) is applied directly to the surface of the object (6), the visibility of which is ensured, and copies its shape.

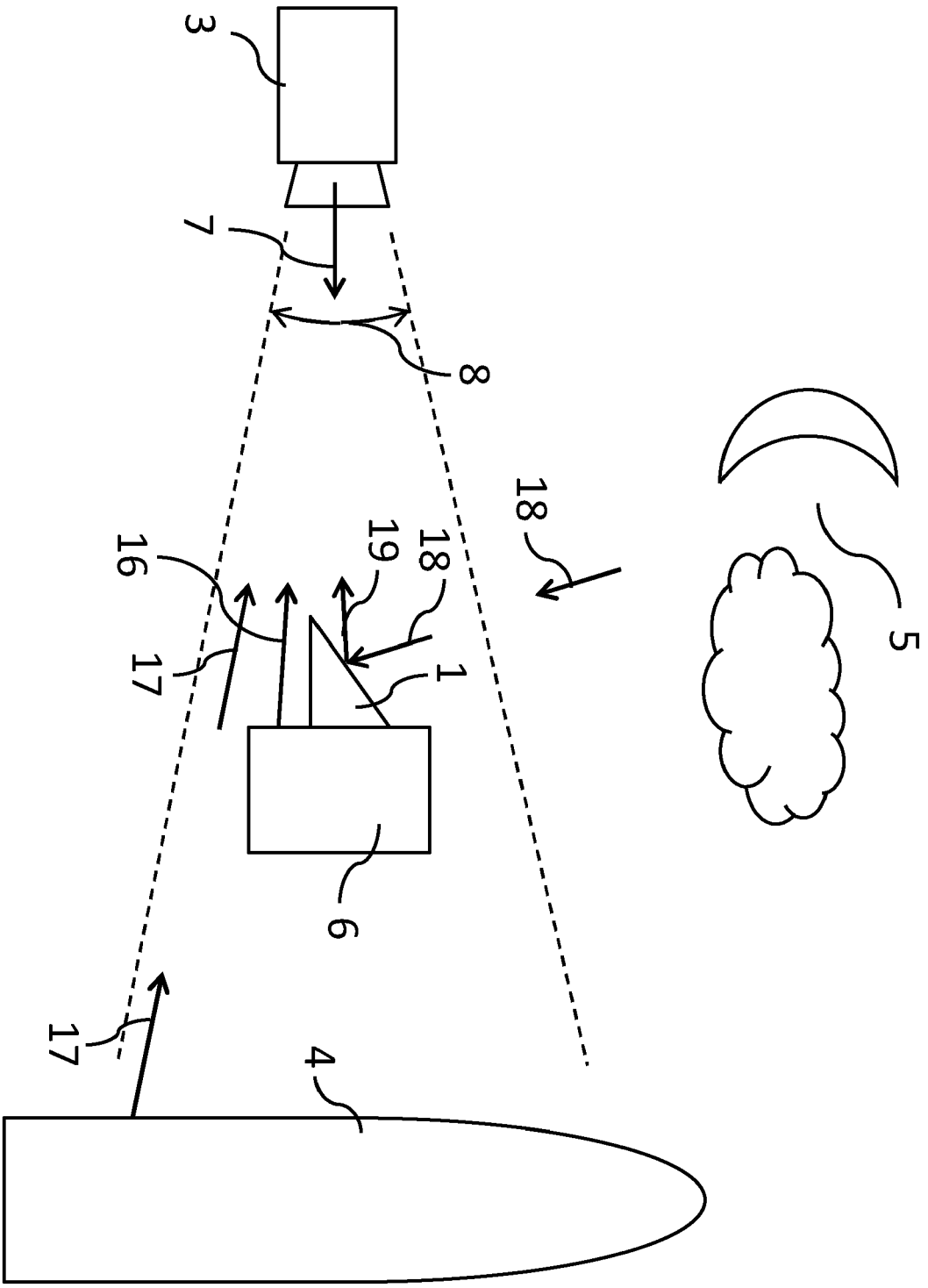


FIG. 1

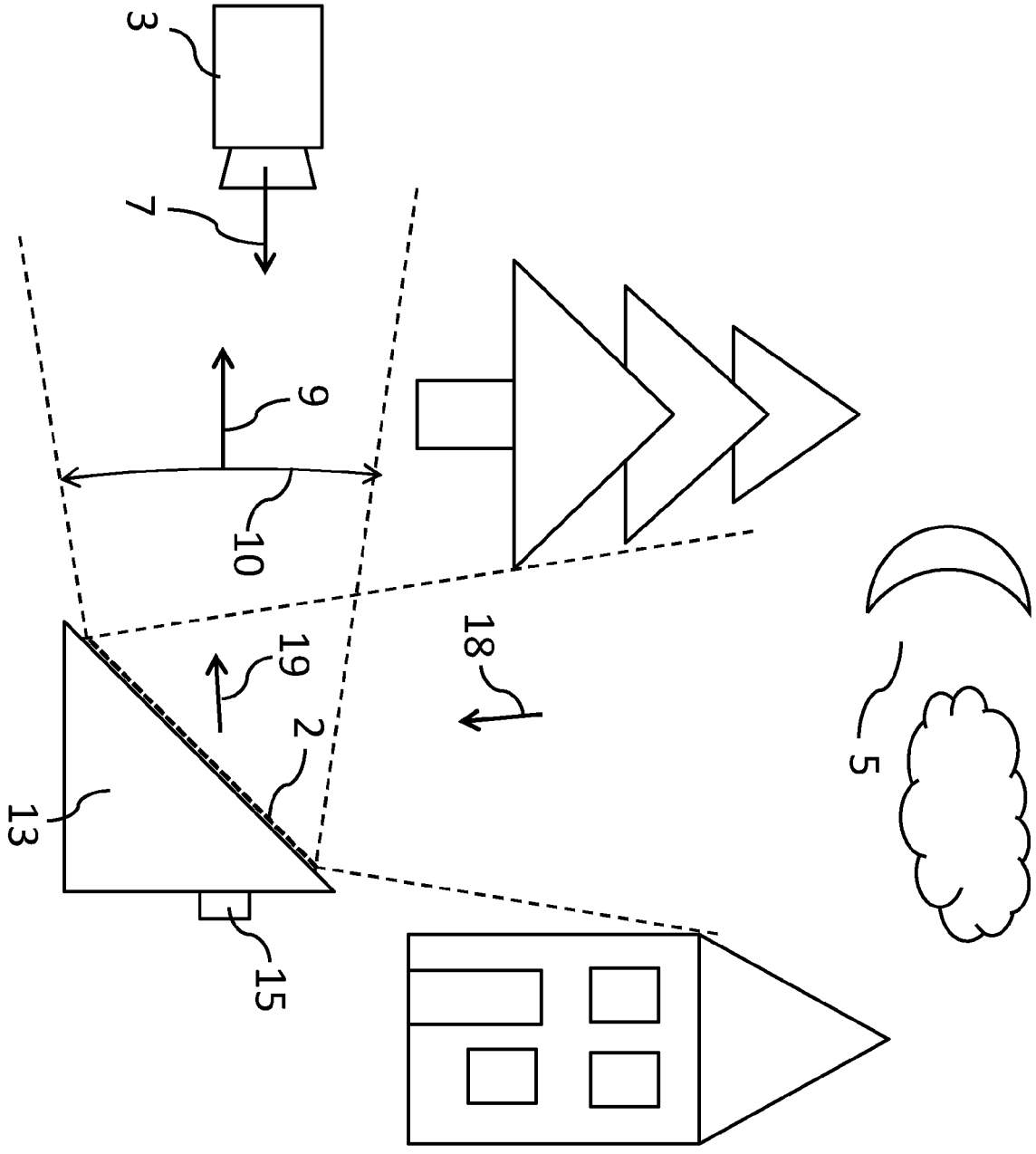


FIG. 2

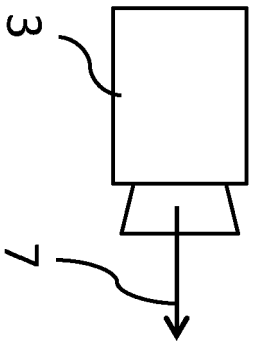
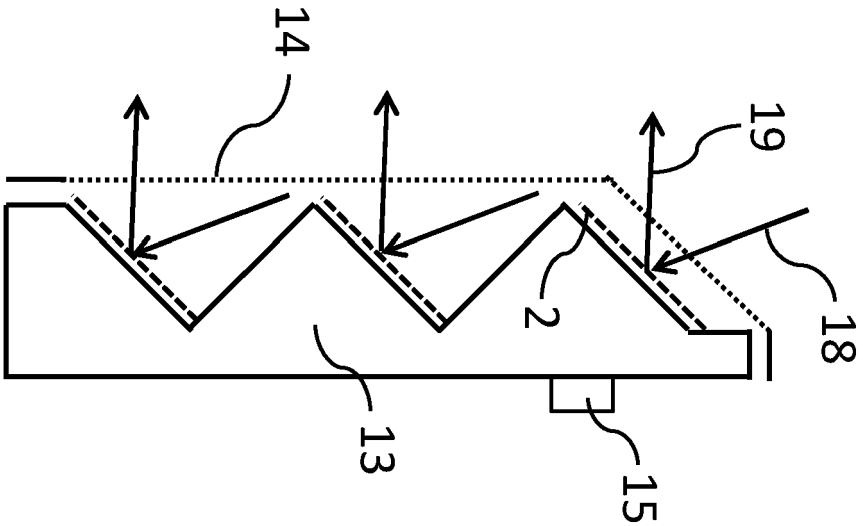


FIG. 3



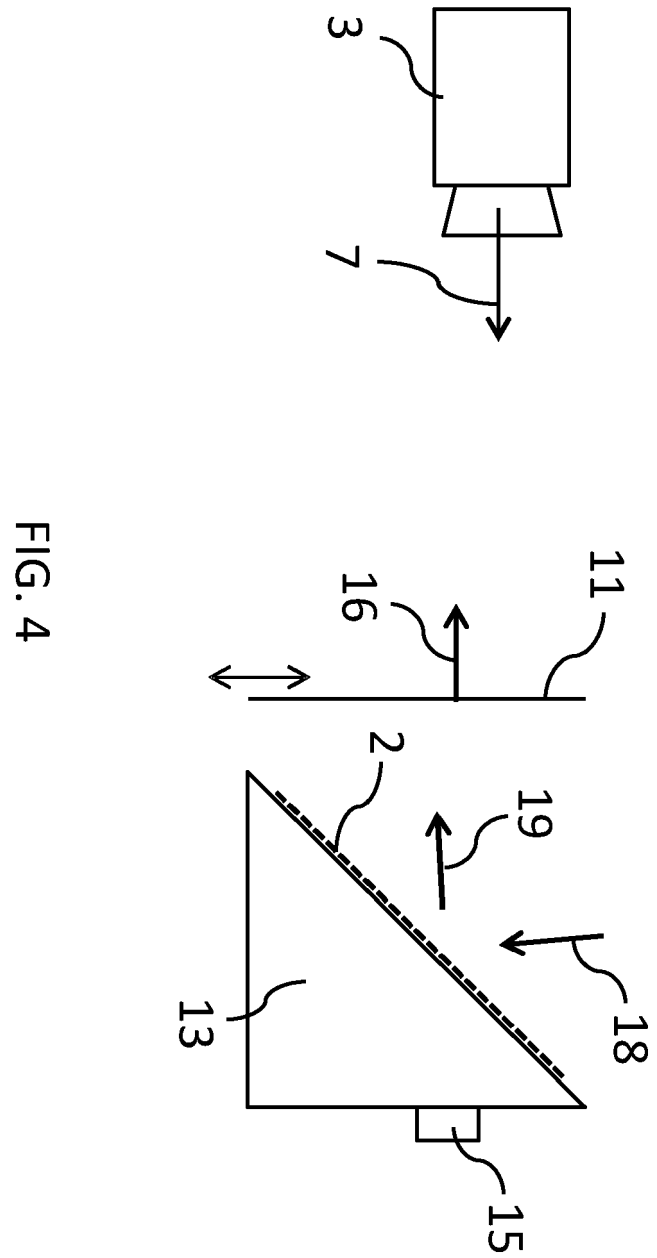


FIG. 4

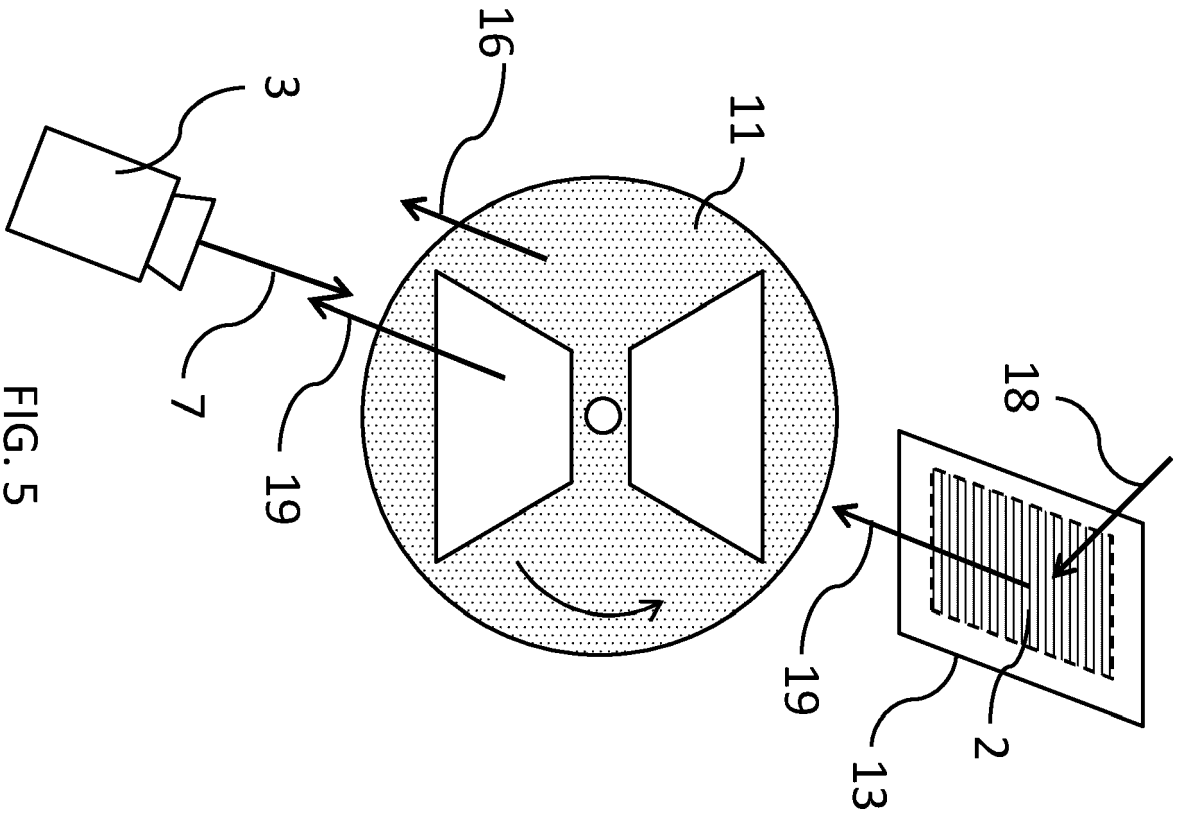


FIG. 5

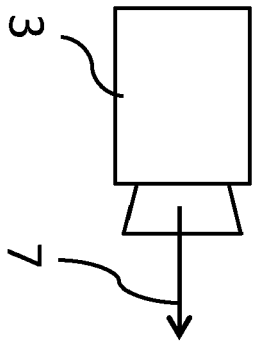
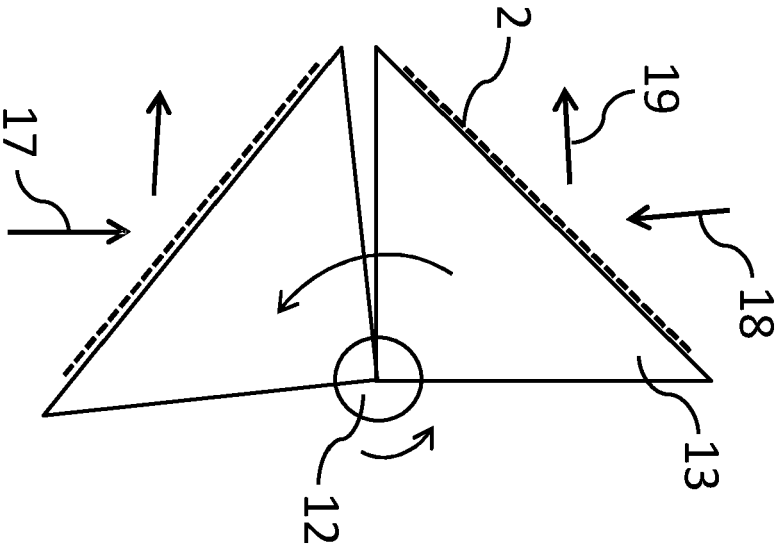


FIG. 6



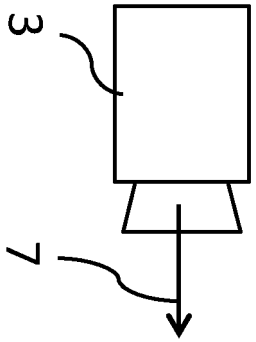
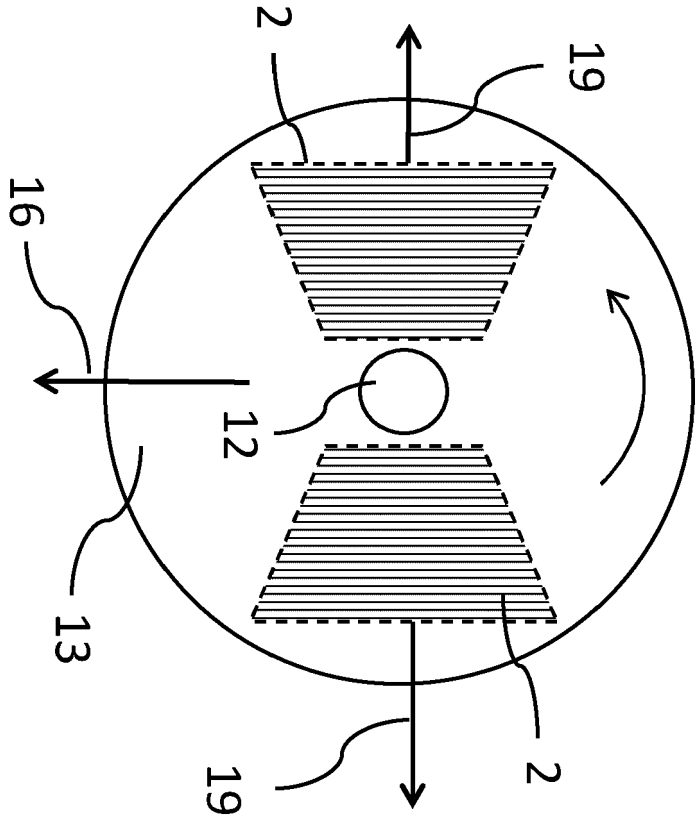


FIG. 7



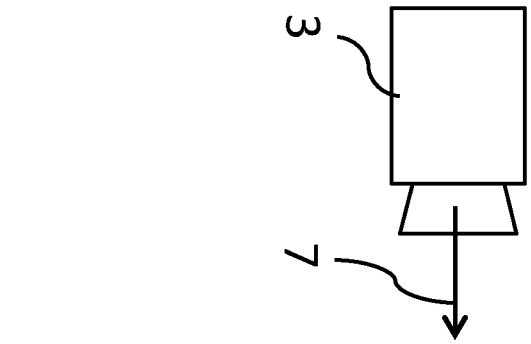
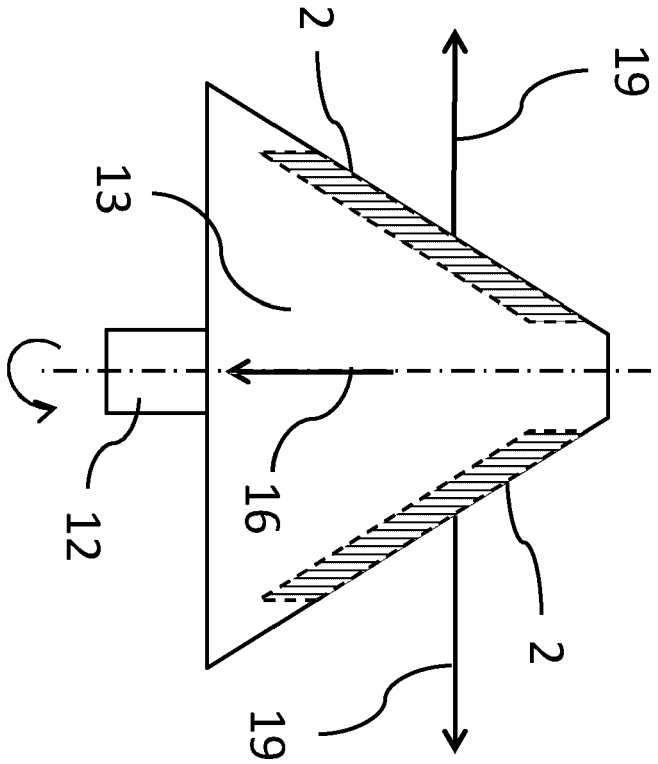


FIG. 8



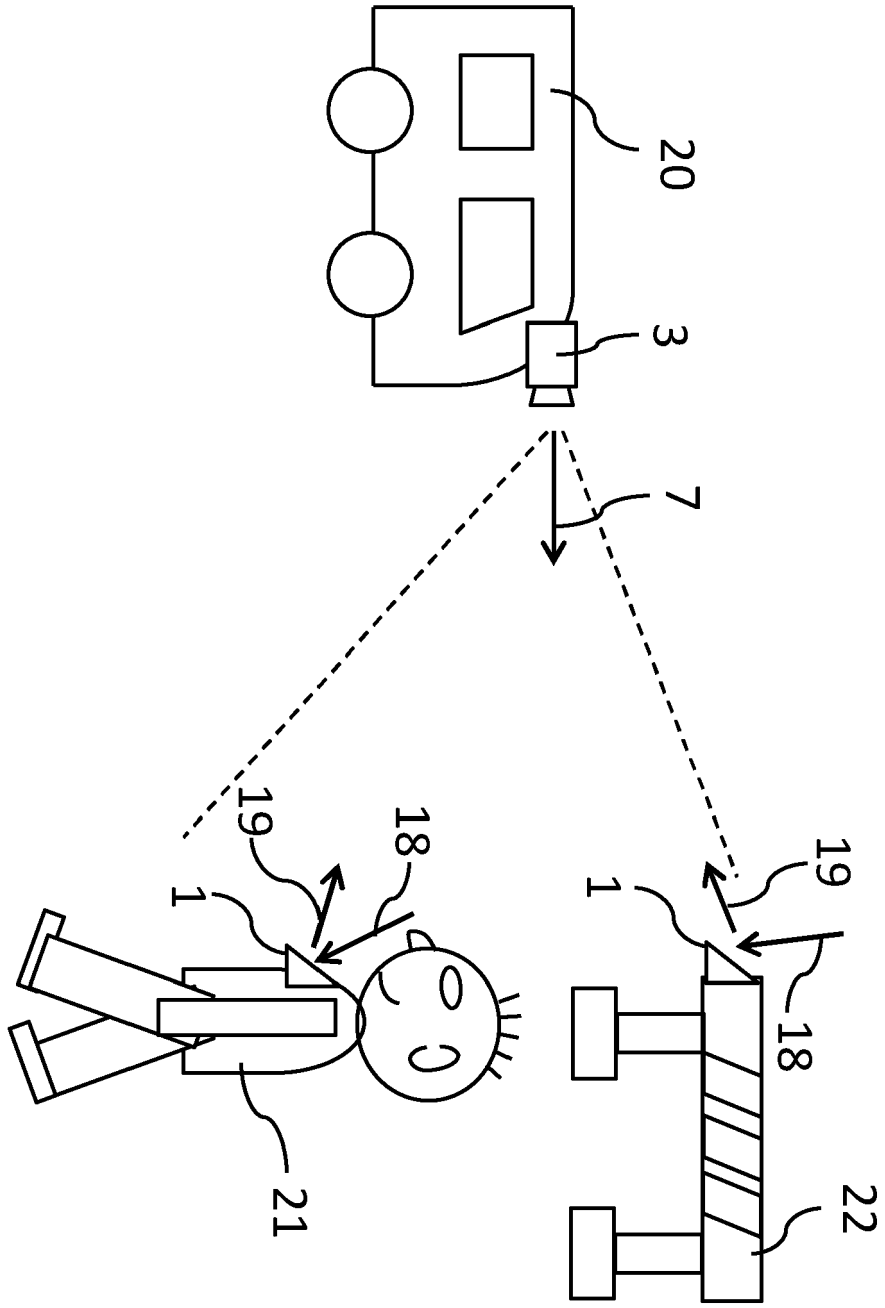


FIG. 9

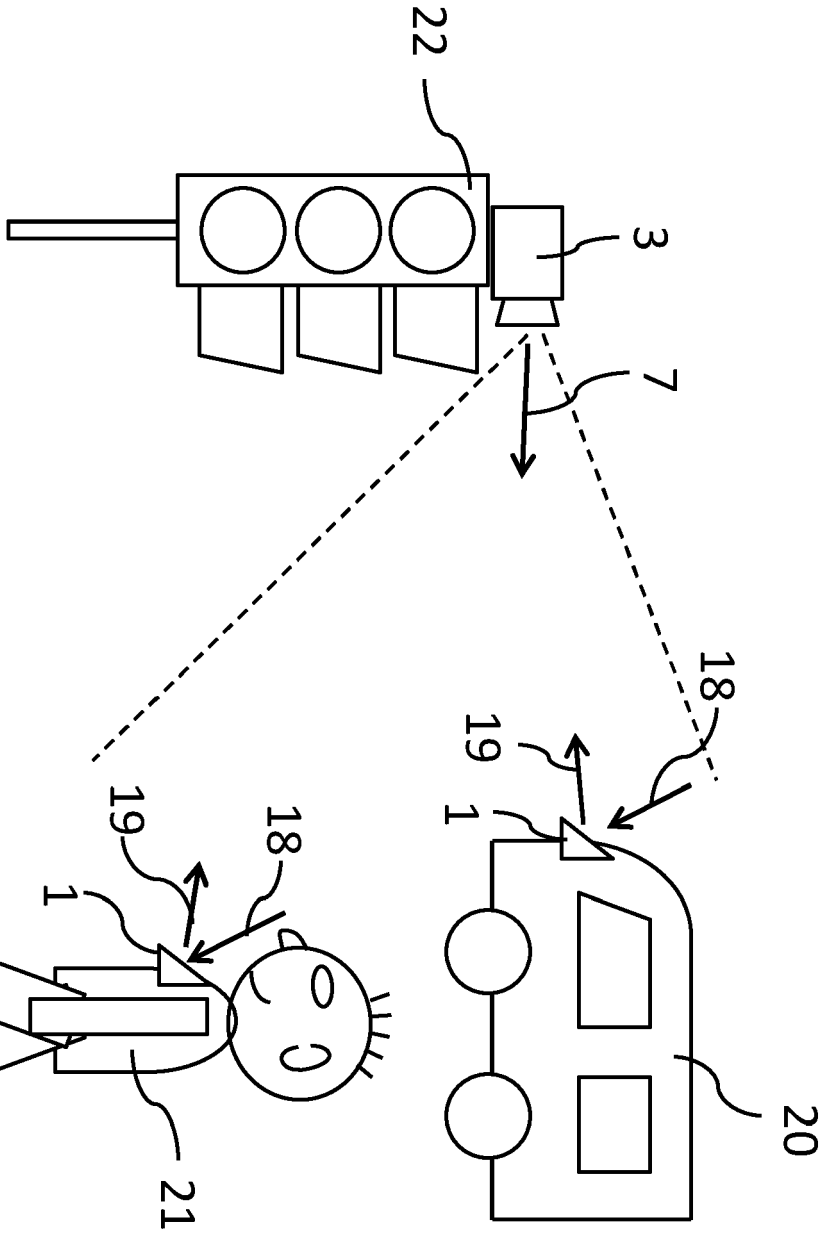


FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 6336

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	KR 102 154 611 B1 (KIM DAE HO [KR]) 10 September 2020 (2020-09-10) * the whole document *	1-7	INV. G08B21/02 G08G1/04 G08B5/00
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TECHNICAL FIELDS SEARCHED (IPC)

G08B
G08G

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 May 2024	Kurzbauer, Werner

CATEGORY OF CITED DOCUMENTS

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13-05-2024

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