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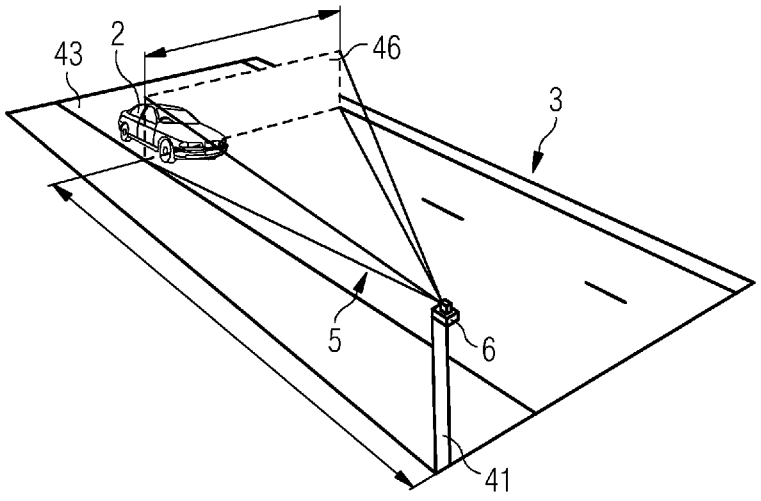
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(54) Title: VEHICLE RECOGNITION SYSTEM AND METHOD

FIG 2



(57) **Abstract:** An automated vehicle identifier recognition system comprises a collimated infrared (IR) radiation source (7) and a steering mechanism to allow the direction of a beam (5) from the IR radiation source to be altered and to scan the beam in a predetermined orientation across a target area (1). The system also comprises a controller (16) to control the steering and scanning, a receiver to receive IR radiation reflected back from the target area (1) and an image processing system (20) to derive an image of the identifier from the received reflected IR radiation.

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VEHICLE RECOGNITION SYSTEM AND METHOD

This invention relates to recognition systems, in particular for automatic number plate recognition.

Conventional number plate recognition systems used, for example for traffic enforcement, parking control, congestion charging, or other similar purposes, either use a high intensity flash light source of near infra red light, such as Xenon, with a reflector behind the light source, or arrays of LEDs, or substantially non-visible infra red illuminators based on LED technology. In these systems a retro-reflective number plate sends the light back in exactly the same direction as it has arrived from. Typically, this reflected light is mostly visible along the axis of the incident light. If the plate is clean and reflective, then even in low light a good image can be obtained. As the flash light source is relatively costly to install and operate, these systems have been superseded by arrays of LEDs, but even LED based systems produce wasted light, so improvements are desired.

In accordance with a first aspect of the present invention, an automated vehicle identifier recognition system, the system comprising a collimated infra red (IR) radiation source, a steering mechanism to allow the direction of a beam from the IR radiation source to be altered and to scan the beam in a predetermined orientation across a target area; a controller to control the steering and scanning; a receiver to receive IR radiation reflected back from the target area; and an image processing system to derive an image of the identifier from the received reflected IR radiation.

The identifier may be one of a vehicle registration number; a vehicle weight identifier; a vehicle chemical warning symbol; a vehicle classification shape; or a commercial vehicle operator licence plate.

Vehicle identifiers may take many forms, as well as standard vehicle number plates. For example, lorry weight identifiers may be required and used to allow or prevent access at monitored bridges, although there is no standardised system in the UK for this. Chemical warning symbols on vehicles may be monitored and used to allow or prevent access to tunnels, or taxi cab licence plates may be used to ensure that only approved taxis pick-up in a particular area. Another application is to identify the vehicle make and model from its characteristic shape. This can be used for vehicle

classification to recognise the number of cars, vans, lorries, buses entering a particular area.

The recognition system may be an alpha numeric or symbol based character recognition system, in particular, an automatic number plate recognition system.

The IR light source may be a laser diode; or an IR LED array and collimating lenses.

The steering mechanism may comprise at least one mirror, or lens, mounted for rotation about an axis for controlling X direction and at least one mirror, or lens, mounted for rotation about an axis for controlling Y direction of the beam.

The steering mechanism may comprise an electronically controlled array of radiation sources.

For example, the array may be switched on and off, the level of brightness controlled, or the direction of scanning controlled.

In accordance with a second aspect of the present invention, a method of automated vehicle identifier recognition comprises controlling steering of a steerable optical device to steer a beam of collimated infra red radiation from a light source to illuminate a target area in which an identifier is expected; steering the optical device to scan the beam across the target area in a predetermined orientation; receiving radiation reflected back from an identifier in the target area for each pass of the scan; and processing the received reflected IR radiation off the target from each pass to derive an image of the identifier.

The method may comprise causing at least one mirror, or lens, mounted for rotation about an axis to controlling movement of the beam in the X direction and at least one mirror, or lens, mounted for rotation about an axis to control movement of the beam in the Y direction.

The method may further comprise comparing the derived image of the identifier with stored images in a database and extracting additional data from the database if a match is found.

An example of an automated vehicle recognition system and method in accordance with the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 illustrates operation of a conventional automatic number plate recognition system;

Figure 2 illustrates operation of a recognition system according to the present invention;

Figure 3 is a block diagram illustrating a system according to the invention;

Figure 4 illustrates an alternative arrangement for one part of the system of Fig.3;

Figure 5 illustrates a scanning grid in an example of a recognition system according to the present invention;

Figure 6a and 6b illustrate exit angles on a spinning device for use in a recognition system according to the present invention;

Figure 7 illustrates an alternative arrangement for another part of the system of Fig.3;

Figure 8 is a flow diagram of a method of automated vehicle identifier recognition according to the invention; and,

Fig.9 illustrates a spinning optical device which may be used in a recognition system according to the invention.

As described above, conventional vehicle number plate recognition systems used flood illumination where the whole area is flooded in infra-red (IR) light by "always on" infra-red illuminators, for example as illustrated in Fig.1. An IR sensitive camera 40 is mounted to a pole 41 with active illumination 42 to provide a camera system that can operate during the day and at night. A vehicle 2 in a lane 43 of a road 3 is illuminated by the active illumination which fall on the lit areas 44, 45. ANPR systems typically recognise an alpha numeric or symbol-based character. The systems use the retroreflective nature of the vehicle's registration plate to get a clear photograph of the registration plates characters or digits with just a small amount of incident IR light. However, this can be a challenge given the long distance that the vehicle may be from the camera when the image is captured. The light from the active illumination 42 both illuminates the scene 44, 45 and returns to the IR camera. For an LED based system using this type of illumination, the LEDs are typically high power infra-red LEDs operating in the range of 800 nm to 970 nm, for example, 850 nm or 950 nm, in an array with fixed lenses fitted in a housing to direct the light. The illuminators are

large and bulky and use a significant amount of power, which may be more than 50 W per illuminator. The typical wavelength of 850nm is chosen on the basis that this is the wavelength where the LEDs are most efficient. At this wavelength there is a faint red glow from the illuminator. For illumination of the vehicle registration plate with near infra-red light to be invisible to the driver, light at 950nm may be used. In any case, the light must be at a wavelength that allows the registration plate to be recorded by a camera that is sensitive to the near infra-red light.

Although LED technology has improved, so that smaller arrays with higher power individual LEDs can be used, it is still necessary to send light to the number plate to illuminate it. Current IR LEDs have very large emission angles, typically of the order of 120 degrees, so they require optical systems to reduce this light to a narrow cone. Invariably, in doing this, light is wasted in the surrounding scenery, rather than just the narrow target area where the registration plate is, which is required to be illuminated. An alternative is to use a pulsed IR illuminator. Using a pulsed IR illuminator is more efficient than an always on illuminator, as the illuminator can be configured to fire at the time the photograph is exposed and then recharge in the long periods between frames. Typical systems use a frame rate of 20 to 30 frames per second. Pulsing the light allows the LEDs to be driven at higher powers than would be possible for constant DC operation. However, the system of Fig.1 has the disadvantage that it is difficult to get an optical system targeted to the capture region of interest and a lot of the IR light is wasted in illuminating the surrounding scenery.

In addition, enforcement agencies would like the systems to operate at even greater distances and wider fields of view than is currently possible. Current systems are typically able to operate at distances of 15 m to 30 m with a field of view from one to three lanes width, where a standard lane width is 3.65 m. It is desirable to be able to illuminate a wider lane width. Increasing the distance from which the system can be illuminated has the effect of increasing the width illuminated, but it is also necessary to increase the resolution of the camera system to get sufficient pixels to decipher a registration plate. For example, a minimum in the order of 10 pixels high is required to use optical character recognition (OCR) to recognise the characters on a registration plate. There are distance limitations with systems using LEDs in standard packaging. The standard packaging puts a limit of 120 degree angle on the light emitted from the LEDs. Optics are used to cast the emitted light forward from the array. A cone of light

is produced, only part of which actually ends up illuminating the number plate, as the system does not know where in the cone the number plate is. Much of the light ends up illuminating the road and surrounding scenery, to no useful effect, yet the power required to do it means that the system power supplies are also larger than is desirable, increasing overall cost and size.

A more efficient technology to use is laser diodes, rather than infra red flood lighting, or LED arrays. The problem with infra red laser diodes is that they are too small to illuminate the whole number plate and only produce what is in effect a laser dot. At the distances used for ANPR systems, typically 25m, a laser illuminator of 2 mm exit diameter will typically have diverged to a circle of diameter 6 mm by the time it hits a non-retroreflective target. With a retroreflective target, such as a registration plate, the illuminated spot may increase to a diameter of the order of 60 mm as a result of internal reflection in the retroreflective material, i.e. a 10 fold increase in spot diameter, due to the internal reflections in the retroreflective material.

The present invention addresses these problems by providing a steerable collimated infra-red light source, allowing the scene to be illuminated more efficiently than a fixed cone of light. The steerable infra red light source may be any suitable type, although preferably invisible to the naked eye, such as a high power LED light source in combination with collimating lenses, or mirrors, or an IR laser, such as an infra-red laser diode. The infra red laser diode may also be chosen to operate at 850nm, for reasons of efficiency, which produces a faint visible glow, or at 950 nm if there is a requirement that the beam is substantially non-visible to the naked eye, being outside the normal range of human vision. The laser light source is more efficient, as there are lower losses in the collimating optics than in an LED light source with collimating lenses.

Fig.2 illustrates an equivalent situation to that of Fig.1, but showing the lighting arrangement of the system of the present invention. Mounted to the pole 41, a system 6 provides an illuminator to illuminate the scene and receptors to receive reflected light from which an image can be derived. The scene 46 illuminated by a beam 5 is well defined compared with the scene 44, 45 in the example of Fig.1 and can be restricted to the width of the carriageway 3 and a predetermined height above it, rather than illuminating large areas in which a vehicle 2 is unlikely to be present.

Fig.3 illustrates an alternative view of the recognition system according to the invention. An environment 1 represented includes a moving vehicle 2 on a road 3, although the invention may also be used in other situations, including for identifying stationary vehicles and for other types of vehicle identifier, such as vehicle weight, chemical warning symbol, classification shape, or commercial licence plate, such as a plate issued by a local authority to a taxi. An illumination trace is indicated by lines 4 showing illumination 5 reaching the vehicle from an illumination and control system 6. The illumination and control system 6 may comprise one or more infra-red light sources 7 powered from one or more power supplies 8 and receiving control signals 17 from a control processing unit 16. The infra red source 7 provides an IR light beam 9 to an optical device which generates a suitable beam 5 of illumination for scanning the scene. In this example the optical device comprises a reflector comprising two mirrors 10, 11, although other arrangements are possible, as described hereinafter. Lenses may be substituted for the mirrors in the examples which follow. The light source may be a laser diode, or LEDs with collimating optics to produce a collimated IR beam. The mirrors 10, 11 are mounted for rotation about respective axes 12, 13. Motors 14, 15 drive the mirrors to control movement of the beam of light 5 in the X-direction and in the Y-direction and steer the beam across the scene 1. The control processing unit 16 provides control signals 18, 19 to the motors and a control signal 17 to the light source 7.

An image recording and processing unit 20 receives reflected light from the scene and generates an image. This may comprise cameras sensitive to near infra red. Digital camera CMOS sensors are sensitive to a much wider range of wavelengths than the human eye, so can detect visual and near infra red. When used in commercial visible light cameras, internal filters remove the sensitivity to the IR, whereas this type of cameras when used for ANPR, uses a digital camera CMOS sensor that has a filter to block out the visible light, but allow the IR to be detected. As the number plate typically contains retro-reflective material which is not normally present in the rest of the scene 1, the illumination of the number plate by the scanning light beam 5 provides a sufficiently good return in most cases, for the image processor 20 to be able to derive an image of the identifier, in this case the number on the number plate, from the return signals.

The spinning reflector 10, 11 is angled so that the light source illuminates the areas of the scene where the registration plate of the vehicle 2 is most likely to be located. The capture region 46 is a plane perpendicular to the traffic flow. Ideally, the system illuminates this region and only this region. This light in its collimated form can travel large distances without loss as it is not affected by the inverse square law that causes divergence of uncollimated light as the light's distance from its source increases. When the light source hits the registration plate, the retro-reflective coating on the registration plate reflects back most of the incident light to a camera system in the image recording and processing unit 16. The collimated nature of the light from the IR light source means that the light is reflected back towards the light source far more efficiently than it would be from a conventional dispersing LED source. The design of the spinning reflector 10, 11 may be adapted to target specific areas of the road scene and the control processing unit 16 may set the angles of the mirrors 10, 11 to control the rate of scanning.

If a laser source is being used to generate the spot being scanned, the spot illumination would be too small for a scanning system that just relies on the material internal reflection to increase its diameter to around 60mm. With this small spot diameter, the number of revolutions required to spin the optic may exceed the performance of motors that are generally available. This problem is addressed by using a lens on the laser 7 to diverge the collimated beam slightly. An appropriate choice of lens that diverges the slot to a diameter of 300 mm at a distance of 25 m then produces a spot of sufficient size. More detail can be seen in Fig.5, illustrating how a collimated laser beam has been diverged, using optics, to a diameter of 300 mm at a distance of 25m can then form a grid of illuminated scan cells. The grid in this example has 40 cells in one direction (across the width of the carriageway to be scanned) and has 8 cells in another direction (perpendicular to, or vertically up, with respect to the road). In the system producing the light beam, the scanning optics sweep horizontally 8 times per revolution and each of the eight horizontal sweeps is in a different vertical angle set by the angled facet of the optics surface. The change in angle may be achieved using a single spinning device of the type illustrated in Figs.6a and 6b, illustrating the maximum exit angle (Fig.6a) and minimum exit angle (Fig.6b).

The system of the present invention provides a steerable IR radiation source which is used to scan the scene at a rapid speed. Scanning may be carried out from side

to side, as shown in Fig.4, with. each successive scan line 21 being further from the left of the scene, for a scan starting on the left, toward the right of the scene, for a scan finishing on the right, or vice versa. However, in Fig.3, the scanning is illustrated as being carried out from top to bottom of the scene, or from bottom to top of the scene, as that increases the chance of the light beam 5 being incident on the registration plate which has a rectangular, landscape, orientation.

For a side to side scan, in the example as shown in Fig.3, the mirrors 10, 11 move the beam 5 from its highest point to its lowest point, or vice versa, at one location at one side, where the scan starts, then repeat this scan from top to bottom, or bottom to top accordingly, a little further towards the other side until the scan reaches the far side of the scene. During scanning, it is more likely that the vehicle will have moved across the road in the sideways direction as it moves forward towards the source of illumination, than that the vehicle will have moved up or down relative to the road surface. This movement of the vehicle is more likely to result in redundant data being collected, or data being missed, over the course of the scan with a top to bottom, or bottom to top scan, where each scan line is below or above the previous one, relative to the road surface. The use of a side to side scan is consistent with the vehicle direction of travel and the vehicle is likely to maintain a more consistent position with respect to the road in the vertical direction during the scanning time. However, a potential benefit of top to bottom scanning, i.e. a scanning method that moves the beam across from one side to the other for each scan line, may be in reducing motion blur of the camera system if the ratio of the scene width/height is greater than 1 for the registration plate width/height.

An alternative embodiment of the optical device to that shown in Fig.3 may be implemented using a micro mirror device, either a micro-electromechanical device, or a digital micro-mirror device, controlled by applying a control voltage, to reflect the light beam from the collimated IR light source in order to modulate the amplitude and direction of the light form the source. A digital micro-mirror device which can be switched between an on state and an off state allows the light to be transmitted, or diverted, according to whether or not there is something to be illuminated. These devices enable finer control of the IR light, but are relatively expensive, as compared with the simpler rotating reflector of Fig.3. In the example of Fig.3, a single light source 7 is shown, with a single mirror 10, 11 controlling each of the X and Y

direction. However, an embodiment as shown in Fig.7, having multiple collimated light sources 7, optionally using multiple spinning reflectors 10 is also possible. The size and location of the second reflector 11 for the Y axis may be altered to ensure that the reflected signal from the first reflector 10 on the X axis is correctly received. The scene 1 is illuminated as before, the processing and control signals having been adapted accordingly. In another embodiment, not shown, more than one spinning optical device, in more than one axis, may be used. The spinning optical devices may be reflectors, such as mirrors, as described, or lenses which control the direction of the light beam by bending the beam as it passes through the lenses. Fig.9 illustrates a spinning optical device which may be used with a laser IR source, either a single device, or multiple sources and multiple devices, rather than needing two mirrors in series per source.

The process for operating a system as illustrated in Fig.3 is described with reference to Fig.8. A first step, 30 which is typically part of the set-up process for the recognition system is to define an area in which a target including an identifier, such as a vehicle number plate, is expected, so that the control system only scans in that area and not, for example, the hedges and trees at the side of the road, or the sky. In addition, the direction of scanning, i.e. whether from side to side, or up and down, may be defined. Illumination 31 of a moving target area may be triggered, for example by a vehicle passing a roadside sensor a certain distance before the target area comes into the field of view of the IR radiation beam. The collimated IR radiation beam 5 from the light source 7 is then scanned 32 across the defined area in the predetermined orientation. IR radiation reflected from the target is received 33 in the image recording and processing unit 20 and from the successive scans, the image processor is able to derive 34 an identifier in the target area. For example, if the identifier is a combination of letters and numbers, on a vehicle plate, the derived characters may be compared with a database and other input information, such as average speed since the same number was recorded as passing a preceding recognition device, or checked to see if the associated vehicle is authorised to enter that location.

In combination, the provision of steerable collimated IR radiation scanning a scene to illuminate a retro-reflective registration plate results in a smaller, lower power illumination system than conventional systems. Using a collimated light source allows the recognition system to produce images at greater distances from the source than

existing systems are able to, as the collimated light is spread over a smaller area and so has sufficient intensity to be effective at the greater distance. Scanning the light source improves efficiency and increases the effective width of the illumination that is possible with a single light source. A product may then fit into a smaller enclosure, use less power and yet provide improved registration plate visibility. The system may be applied to other situations were a tightly controlled IR beam is required to illuminate an object at a distance, such as for illumination for traffic yellow box junction infringement, or parking, or lane enforcement, or controlling entry of specific types of vehicle, or cargo on the vehicle, to particular areas.

CLAIMS

1. An automated vehicle identifier recognition system, the system comprising a collimated infra red (IR) radiation source, a steering mechanism to allow the direction of a beam from the IR radiation source to be altered and to scan the beam in a predetermined orientation across a target area; a controller to control the steering and scanning; a receiver to receive IR radiation reflected back from the target area; and an image processing system to derive an image of the identifier from the received reflected IR radiation.

2. A system according to claim 1, wherein the identifier is one of a vehicle registration number; a vehicle weight identifier; a vehicle chemical warning symbol; a vehicle classification shape; or a commercial vehicle operator licence plate.

3. A system according to claim 1 or claim 2, wherein the recognition system is an alpha numeric or symbol based character recognition system, in particular, an automatic number plate recognition system.

4. A system according to any preceding claim, wherein the IR light source is a laser diode; or an IR LED array and collimating lenses.

5. A system according to any preceding claim, wherein the steering mechanism comprises at least one mirror, or lens, mounted for rotation about an axis for controlling X direction and at least one mirror, or lens, mounted for rotation about an axis for controlling Y direction of the beam.

6. A system according to any preceding claim, wherein the steering mechanism comprises an electronically controlled array of radiation sources.

7. A method of automated vehicle identifier recognition, the method comprising controlling steering of a steerable optical device to steer a beam of collimated infra red radiation from a light source to illuminate a target area in which an identifier is expected; steering the optical device to scan the beam across the target area in a

predetermined orientation; receiving radiation reflected back from an identifier in the target area for each pass of the scan; and processing the received reflected IR radiation off the target from each pass to derive an image of the identifier.

8. A method according to claim 7, wherein the method comprises causing at least one mirror, or lens, mounted for rotation about an axis to controlling movement of the beam in the X direction and at least one mirror, or lens, mounted for rotation about an axis to control movement of the beam in the Y direction.

9. A method according to claim 7 or claim 8, wherein the method further comprises comparing the derived image of the identifier with stored images in a database and extracting additional data from the database if a match is found.

FIG 1

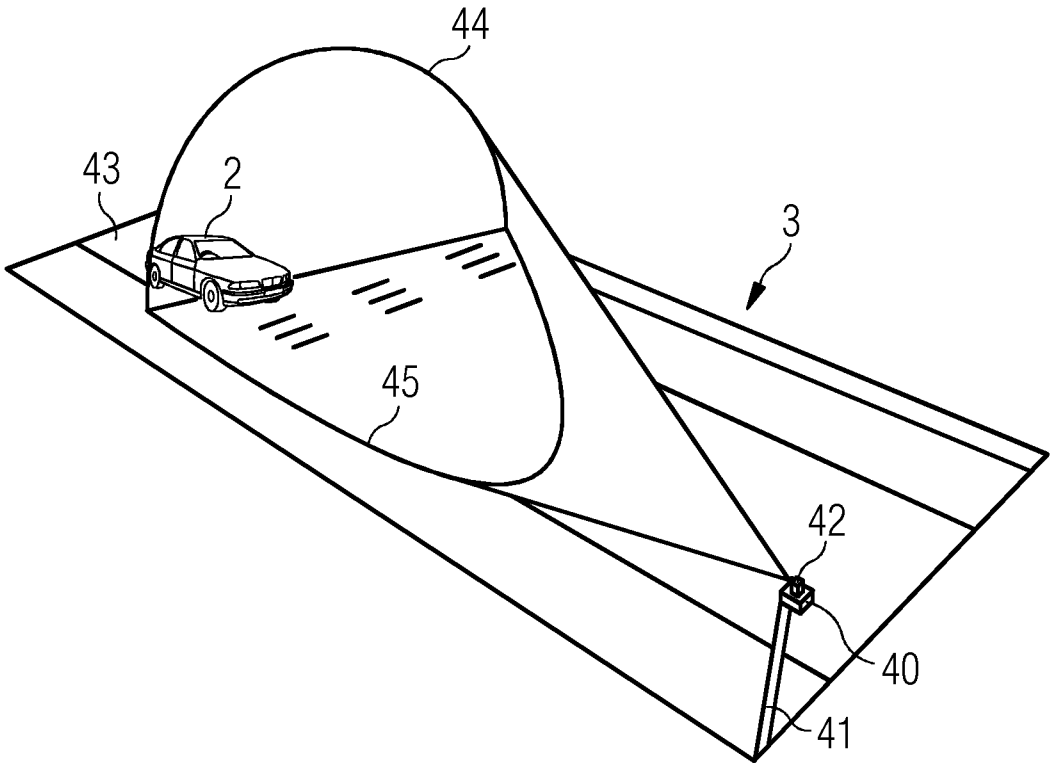
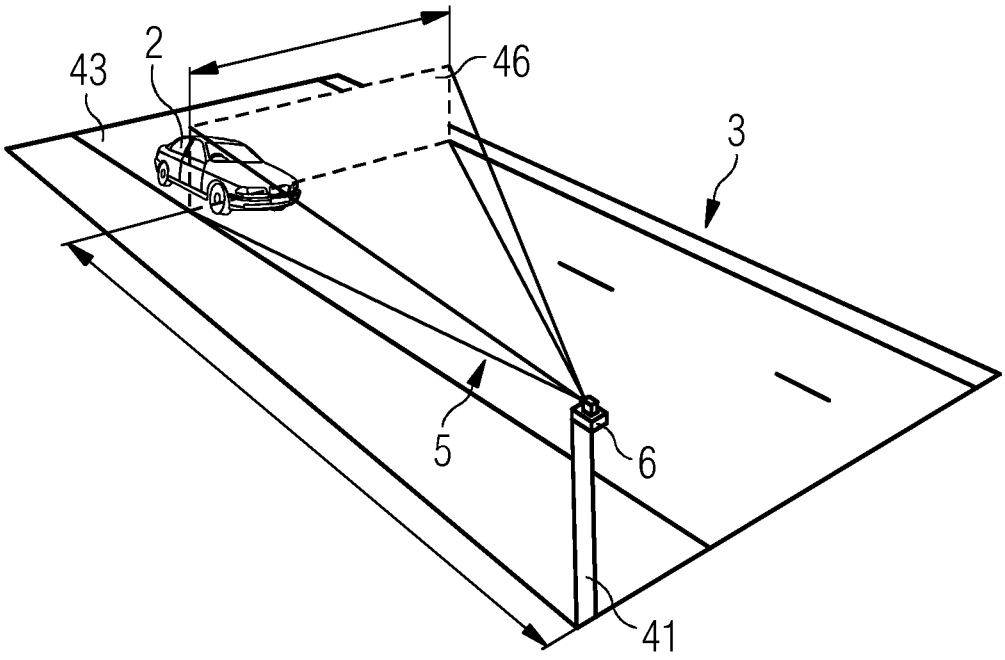


FIG 2



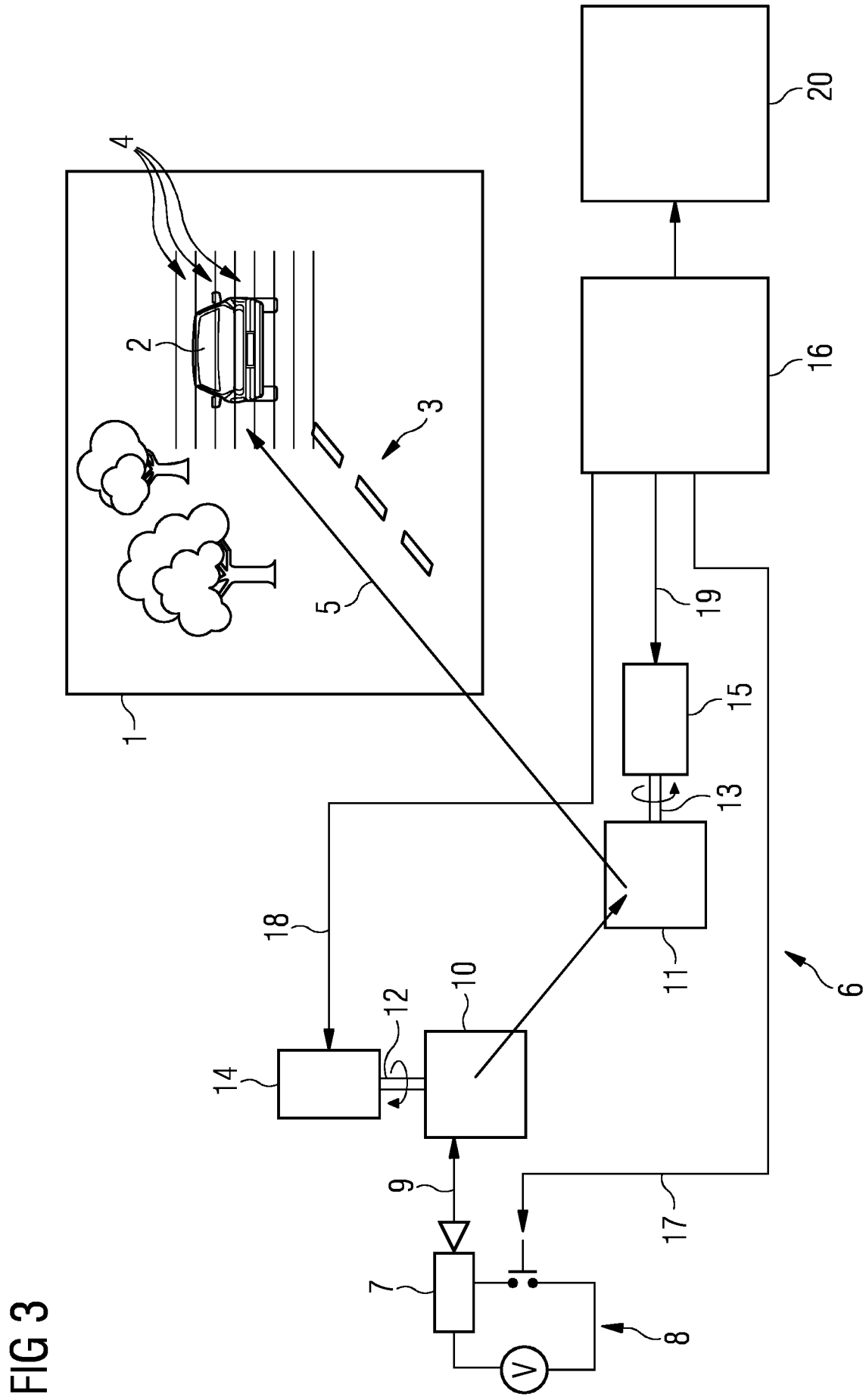


FIG 3

FIG 4

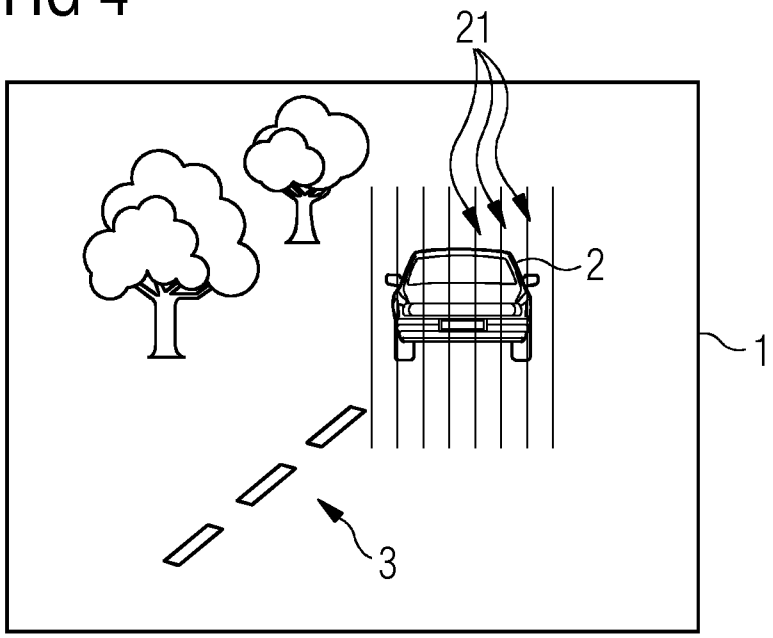


FIG 5

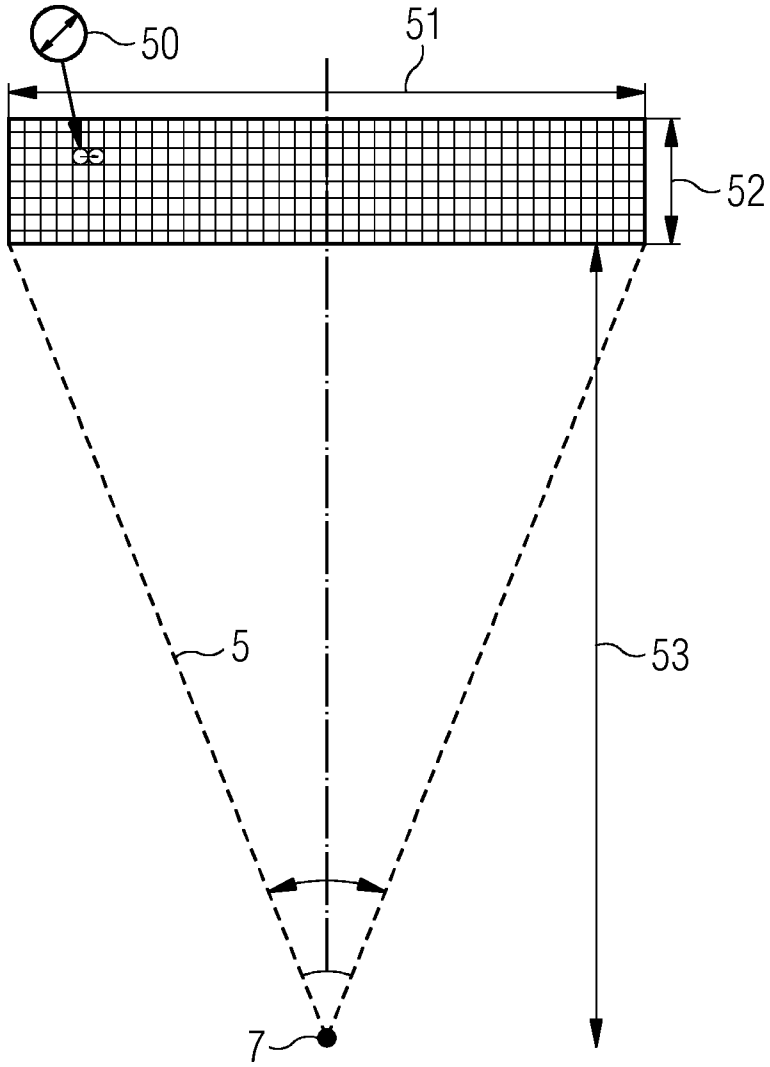


FIG 6A

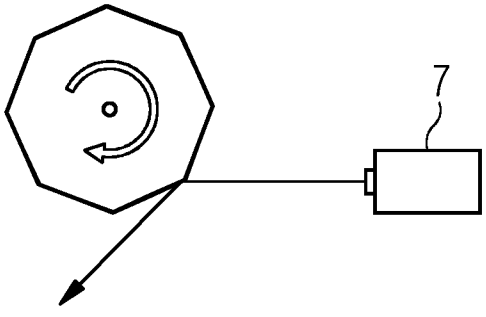
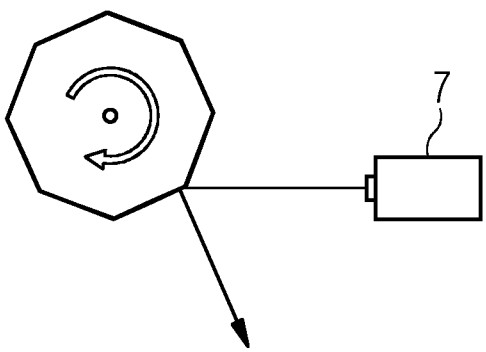


FIG 6B



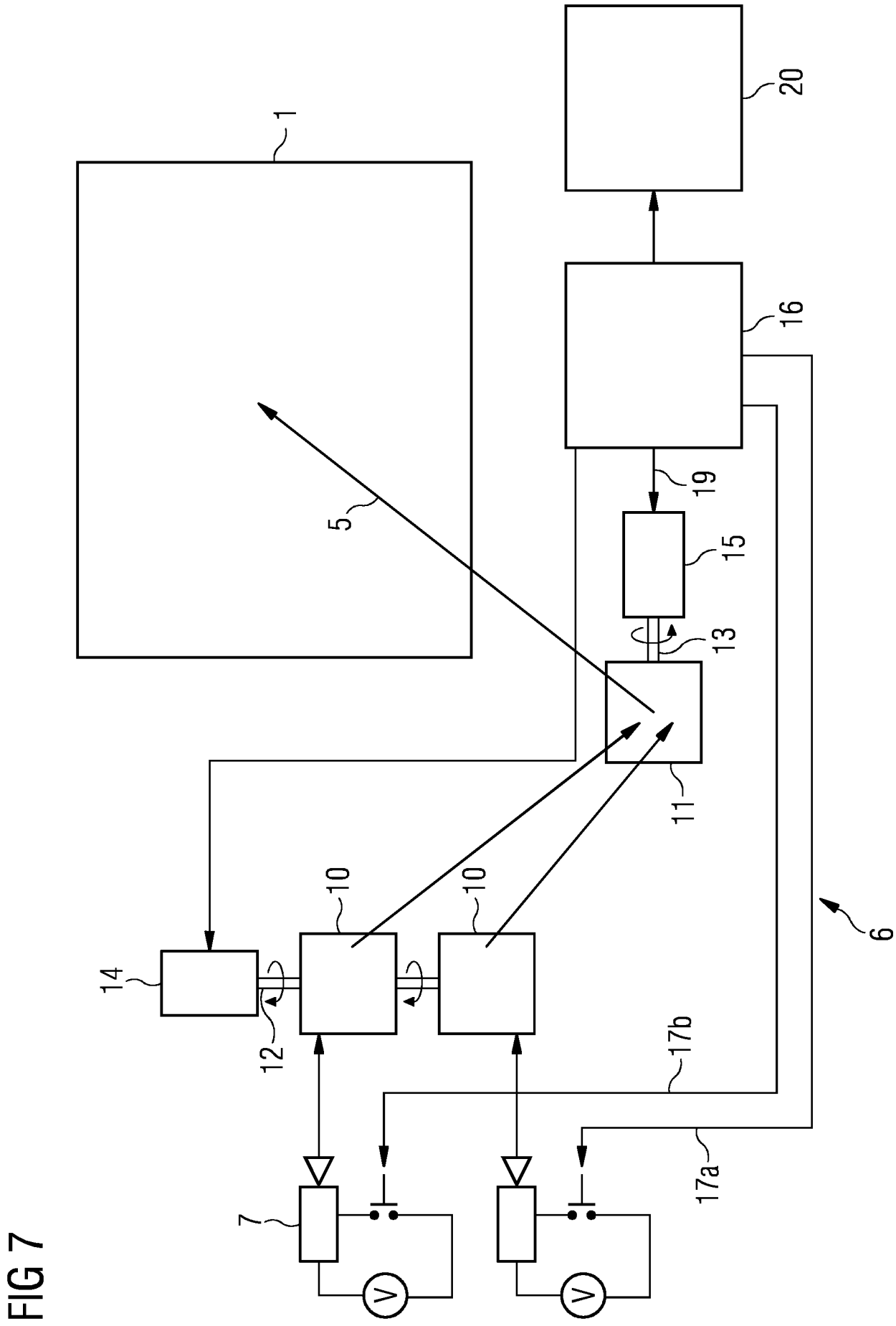


FIG 7

FIG 8

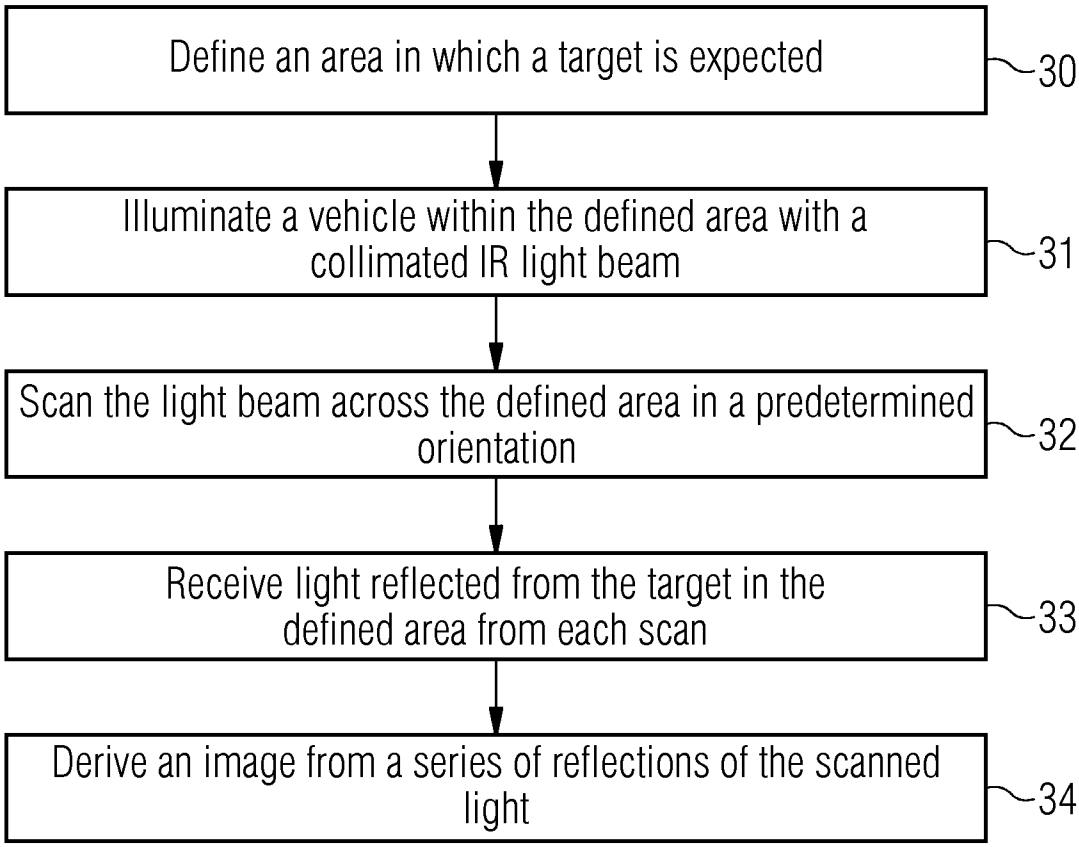
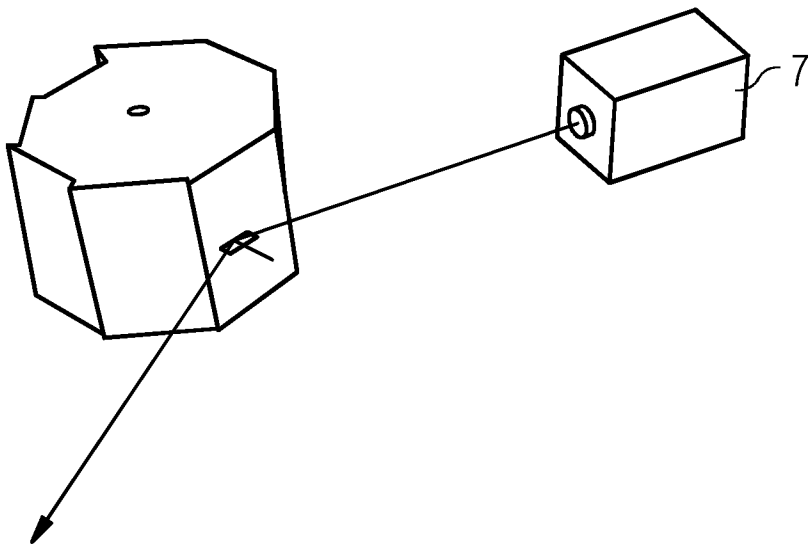

Define an area in which a target is expected
30
Illuminate a vehicle within the defined area with a collimated IR light beam
31
Scan the light beam across the defined area in a predetermined orientation
32
Receive light reflected from the target in the defined area from each scan
33
Derive an image from a series of reflections of the scanned light
34

FIG 9


7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/083355

A. CLASSIFICATION OF SUBJECT MATTER
INV. G07B15/06
ADD.

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)
G07B G06K G08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 615 051 A1 (NISSAN MOTOR [JP]) 11 January 2006 (2006-01-11) paragraphs [0020], [0022], [0024], [0025], [0030]	1,7
X	US 2011/063446 A1 (MCMORDIE DAVID [CA] ET AL) 17 March 2011 (2011-03-17) paragraphs [0005], [0009], [0029], [0042], [0046], [0047]; claim 10; figures 1-8	1-9
A	US 2004/170017 A1 (ZHAN JAMES [CA] ET AL) 2 September 2004 (2004-09-02) paragraph [0019] - paragraph [0032]; figures 1-6	1,6

☐ Further documents are listed in the continuation of Box C.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2019/083355

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