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(54) Title: AUTOMOTIVE LIGHTING DEVICE

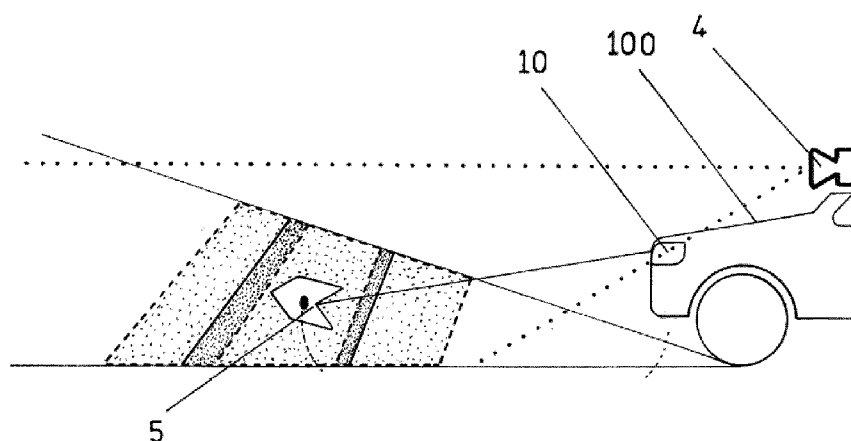


Fig. 2

(57) **Abstract:** The invention provides a method for achieving a correct aiming of an automotive lighting device (10), comprising the steps of providing a predetermined light pattern comprising a reference portion, acquiring an image of the predetermined light pattern comprising the reference portion and identifying the position of the reference portion in the acquired image. The reference portion is designed to be located at a reference distance from the automotive lighting device when the lighting device is correctly aimed. Then, an actual distance between the position of the automotive lighting device and the position of the reference portion is measured, then comparing the actual distance with the reference distance thus resulting a biasing value. Finally, the position of the automotive lighting device is corrected depending on the biasing value.



Description

Title: Automotive lighting device

This invention is related to the field of automotive lighting devices, and more particularly, to the improvement of luminous efficiency in these devices.

5 Automotive lighting market can be considered as one of the most competitive ones and new lighting functionalities are constantly required.

Some lighting modules are required to provide more than one different functionality. To achieve this aim, there are many options in the market which combine the low beam and the high beam functionalities.

10 Current devices need to provide levelling and aiming features so that the beam is well adjusted and glaring is prevented. Further, a good adjustment of the beam is also required for a good operation of smart functionalities.

Current solutions involve mechanical sensors to sense the inclination of the vehicle and then adjust the inclination of the lighting device to compensate it.

15 The invention provides an alternative solution for this problem by a method for achieving a correct aiming of an automotive lighting device, the method comprising the steps of

- providing a predetermined light pattern comprising a reference portion, wherein the reference portion is designed to be located at a reference distance from the automotive lighting device when the lighting device is correctly aimed;
- 20 – acquiring an image of the predetermined light pattern comprising the reference portion by some image acquisition means;
- identifying the position of the reference portion in the acquired image;
- measuring an actual distance between the position of the automotive lighting device and the position of the reference portion in the acquired image;
- 25 – comparing the actual distance with the reference distance thus resulting a biasing value; and

- correcting the position of the automotive lighting device depending on the biasing value.

In some particular embodiments, the reference portion is a portion of a high beam light pattern, or a portion of a low beam light pattern, or a portion of a spot light pattern, or a portion of a pictogram.

These type of projections have zones which may be easily considered as reference zones, and therefore easily measured by image acquisition means.

In some particular embodiments, the step of measuring the actual distance is performed more than once, and a processed actual distance is used in the step of comparing the actual distance with the reference distance.

A single measurement is enough when the car is stopped and the road is flat, so the measurement is not influenced by the body tilt or by the road inclination. However, when the vehicle is in motion, different measurements may be performed to ensure a correct actual distance to be compared with the reference distance.

In some particular embodiments, the steps of measuring the actual distance are performed with different time intervals between each other.

Hence, a kind of “random effect” is achieved, improving the aim of the measurements.

In some particular embodiments, the processed actual distance is obtained by selecting the values which are closer to the reference distance and obtaining the average value of the selected values.

Distance values may vary if the road is ascending or descending, thus providing values which are very far from the reference ones. Provided the deviation from the correct aiming is low, the closest values may be chosen to perform the correction.

In some particular embodiments, the step of selecting the values comprises choosing the mode of the set of values and choosing all the values within a threshold over and below said mode.

This particular way of choosing the values considers that most of the time, the vehicle is on a flat road, so the mode (the most repeated value) will correspond to

the values on flat road. Choosing a threshold over and below and obtaining the average value will improve the accuracy of the method.

In some particular embodiments, the actual distance values are considered with only one digit in the fractional part.

5 Choosing just one digit in the fractional part will make it easier to obtain repeated values, so that the mode may be easily found.

In some particular embodiments, the step of identifying the position of the reference portion in the acquired image is carried out by a control unit which is

- 10 – trained to identify the position of a reference portion in training acquired images; and
- tested by comparing the identified positions with the real positions.

This way of training the control unit is useful since provides the control unit with the ability to identify the position of a reference portion in an improved way.

15 In some particular embodiments, the step of comparing the actual distance with the reference distance is carried out by a control unit which is

- trained to compare an actual distance with a reference distance in training acquired images; and
- tested by comparing the obtained results with real results.

20 This way of training the control unit is useful since provides the control unit with the ability to compare distances in an improved way.

In some particular embodiments, the step of training the control unit comprises the use of a machine learning algorithm.

25 This machine learning algorithm may be used both in the identification of the position of a reference portion and/or in the distance comparison. Each one of the two options follows its own machine learning algorithm. Once the corresponding results are validated, the values of the control unit are used to the corresponding steps of the method of the invention.

In a further inventive aspect, the invention provides a data processing element comprising means for carrying out the steps of a method according to the first

inventive aspect and a computer program comprising instructions which, when the program is executed by a control unit, cause the control unit to carry out the steps of a method according to the first inventive aspect.

5 In a further inventive aspect, the invention provides an automotive lighting device comprising:

- an arrangement of light sources;
- a camera configured to acquire external images; and
- a control unit for performing the steps of the method according to the first inventive aspect.

10 In some particular embodiments, the light source arrangement is a matrix arrangement comprising at least 2000 solid-state light sources.

The term "solid state" refers to light emitted by solid-state electroluminescence, which uses semiconductors to convert electricity into light. Compared to incandescent lighting, solid state lighting creates visible light with
15 reduced heat generation and less energy dissipation. The typically small mass of a solid-state electronic lighting device provides for greater resistance to shock and vibration compared to brittle glass tubes/bulbs and long, thin filament wires. They also eliminate filament evaporation, potentially increasing the lifespan of the illumination device. Some examples of these types of lighting comprise semiconductor light-
20 emitting diodes (LEDs), organic light-emitting diodes (OLED), or polymer light-emitting diodes (PLED) as sources of illumination rather than electrical filaments, plasma or gas.

Unless otherwise defined, all terms (including technical and scientific terms) used herein are to be interpreted as is customary in the art. It will be further understood
25 that terms in common usage should also be interpreted as is customary in the relevant art and not in an idealised or overly formal sense unless expressly so defined herein.

In this text, the term "comprises" and its derivations (such as "comprising", etc.) should not be understood in an excluding sense, that is, these terms should not be interpreted as excluding the possibility that what is described and defined may
30 include further elements, steps, etc.

To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate an embodiment of the invention, which should not be interpreted as restricting the scope of the invention, but just as an example of how the invention can be carried out. The drawings comprise the following figures:

Fig 1 shows a general perspective view of an automotive lighting device according to the invention.

Fig 2 shows some steps of the operation of this lighting device.

Fig 3a and Fig 3b show an example of a beam which is not correctly aimed and a beam which is correctly aimed.

Elements of the example embodiments are consistently denoted by the same reference numerals throughout the drawings and detailed description where appropriate:

15	1	Headlamp
	2	LED
	2	Control unit
	4	Camera
	5	Pictogram

20	6	100 Automotive vehicle
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The example embodiments are described in sufficient detail to enable those of ordinary skill in the art to embody and implement the systems and processes herein described. It is important to understand that embodiments can be provided in many alternate forms and should not be construed as limited to the examples set forth herein.

Accordingly, while embodiment can be modified in various ways and take on various alternative forms, specific embodiments thereof are shown in the drawings and described in detail below as examples. There is no intent to limit to the particular forms disclosed. On the contrary, all modifications,

equivalents, and alternatives falling within the scope of the appended claims should be included. Elements of the example embodiments are consistently denoted by the same reference numerals throughout the drawings and detailed description where appropriate.

5 Fig 1 shows a general perspective view of an automotive lighting device according to the invention.

9 This headlamp 1 is installed in an automotive vehicle 100 and comprises

- a matrix arrangement of LEDs 2, intended to provide a light pattern;
- a control unit 3 to perform a control of the operation of the LEDs 2; and
- 10 – a camera 4 intended to acquire external images of a light pattern projected by the LEDs 2.

10 This matrix configuration is a high-resolution module, having a resolution greater than 2000 pixels. However, no restriction is attached to the technology used for producing the projection modules.

15 11 The control unit, previously to its installation in the automotive headlamp, has undergone two training processes.

12 Both training processes comprise some machine learning steps, where the control unit is trained with training data provided by the plurality of sensors.

13 The first training process is concerning the identification of the position of a
20 reference portion. This first training process comprises

- training the control unit to identify the position of a reference portion in training acquired images; and
- testing the control unit comparing the identified positions with the real positions.

25 14 Different reference portions are provided, and the distance is calculated for each one, due to the aforementioned algorithm.

15 The second training process is concerning the distance comparison. This second training process comprises

- training the control unit to compare an actual distance with a reference distance in training acquired images; and
- testing the control unit comparing the obtained results with the real results.

16 In this case, different measurements are provided and the control unit is
5 trained to calculate the correct biasing value.

17 Once both training processes are finished, the control unit is installed in an
automotive vehicle 100 of Fig 2, to perform the luminous control of the headlamp 1. In
any event, these training and testing processes could also be performed during the
operation of the control unit, instead of previously to their installation.

10 18 Fig 2 shows the operation of this lighting device. A predetermined light
pattern is provided by the lighting device, according to the lighting functionality
selected by the vehicle user. This predetermined light pattern comprises a reference
portion, which in this case is a particular pictogram.

19 This pictogram 5 is designed to be projected at a reference distance from
15 the lighting device. When the vehicle is stopped, a single measurement is carried out
to measure which is the distance between the reference portion of the pictogram with
respect to the lighting device.

20 This actual distance is compared to the ideal reference distance, and then
a biasing value is obtained.

20 21 This biasing value will indicate if the beam is too high (and therefore, it
should be lowered) or is too low (and therefore, it should be raised).

22 When the vehicle is in motion, a single measurement would be risky, since
the vehicle is not always running on straight road. Hence, a set of measurements is
taken. These measurements will comprise data when the vehicle is climbing, when the
25 vehicle is horizontal and when the vehicle is going down. The measurements which
are interesting for correcting the aim of the beam are the measurements of horizontal
cruise.

23 By means of a machine learning algorithm, these measurements are
obtained. An example of this algorithm would be to obtain the mode value of all the
30 set values and then choose all the values within a predetermined threshold (for

example, 10% above and over this mode value. Then, the average value is obtained for the selected value, and this is taken as the actual distance, to be compared with the reference distance.

24 For example, if the set of measurements include these measurements: 3.3,
5 3.5, 5.4, 5.5, 5.7, 5.5, 5.6, 5.5, 5.8, 6.1, 6.3, the mode value will be 5.5. Values within a range from -10% to +10% of 5.5 are selected: 5.4, 5.5, 5.7, 5.5, 5.6, 5.5, 5.8. The average value is then calculated: 5.57. If the reference distance is, for example, 5.2, the beam needs to be aimed to reduce the distance of the reference portion in 0.37 m.

25 Fig 3a and Fig 3b shows an example of a beam which is not correctly aimed
10 and a beam which is correctly aimed. In this case, the tunnel function will not work properly if the beam is not correctly aimed, thus glaring the driver of the opposite vehicle.

Claims

1. Method for achieving a correct aiming of an automotive lighting device (10), the method comprising the steps of
 - 5 – providing a predetermined light pattern comprising a reference portion (5), wherein the reference portion (5) is designed to be located at a reference distance from the automotive lighting device (10) when the lighting device is correctly aimed;
 - acquiring an image of the predetermined light pattern comprising the reference portion by some image acquisition means;
 - 10 – identifying the position of the reference portion (5) in the acquired image;
 - measuring an actual distance between the position of the automotive lighting device (10) and the position of the reference portion in the acquired image;
 - comparing the actual distance with the reference distance thus resulting a biasing value; and
 - 15 – correcting the position of the automotive lighting device (10) depending on the biasing value.
2. Method according to claim 1, wherein the reference portion is a portion of a high beam light pattern, or a portion of a low beam light pattern, or a
20 portion of a spot light pattern, or a portion of a pictogram.
3. Method according to any of the preceding claims, wherein the step of measuring the actual distance is performed more than once, and a processed actual distance is used in the step of comparing the actual distance with the reference distance.
- 25 4. Method according to claim 3, wherein the steps of measuring the actual distance are performed with different time intervals between each other.
5. Method according to any of claims 3 or 4, wherein the processed actual distance is obtained by selecting the values which are closer to the

reference distance and obtaining the average value of the selected values.

- 5
6. Method according to claim 5, wherein the step of selecting the values comprises choosing the mode of the set of values and choosing all the values within a threshold over and below said mode.
7. Method according to any of claims 3 to 6, wherein the actual distance values are considered with only one digit in the fractional part.
8. Method according to any of the preceding claims, wherein the step of identifying the position of the reference portion in the acquired image is carried out by a control unit which is
- 10
- trained to identify the position of a reference portion in training acquired images; and
 - tested to compare the identified positions with the real positions.
9. Method according to any of the preceding claims, wherein the step of comparing the actual distance with the reference distance is carried out by a control unit which is
- 15
- trained to compare an actual distance with a reference distance in training acquired images; and
 - tested to compare the obtained results with the real results.
10. Method according to any of claims 8 or 9, wherein the step of training the control unit comprises the use of a machine learning algorithm.
- 20
11. Data processing element comprising means for carrying out the steps of a method according to any of the preceding claims.
12. Computer program comprising instructions which, when the program is executed by a control unit, cause the control unit to carry out the steps of a method according to any of claims 1 to 10.
- 25
13. Automotive lighting device comprising:
- an arrangement of light sources (2);
 - a camera (4) configured to acquire external images; and

- a control unit (3) for performing the steps of the method according to any claims 1 to 9.

14. Automotive lighting device (1) according to claim 13, wherein the light source arrangement is a matrix arrangement comprising at least 2000 solid-state light sources (2).

DRAWINGS

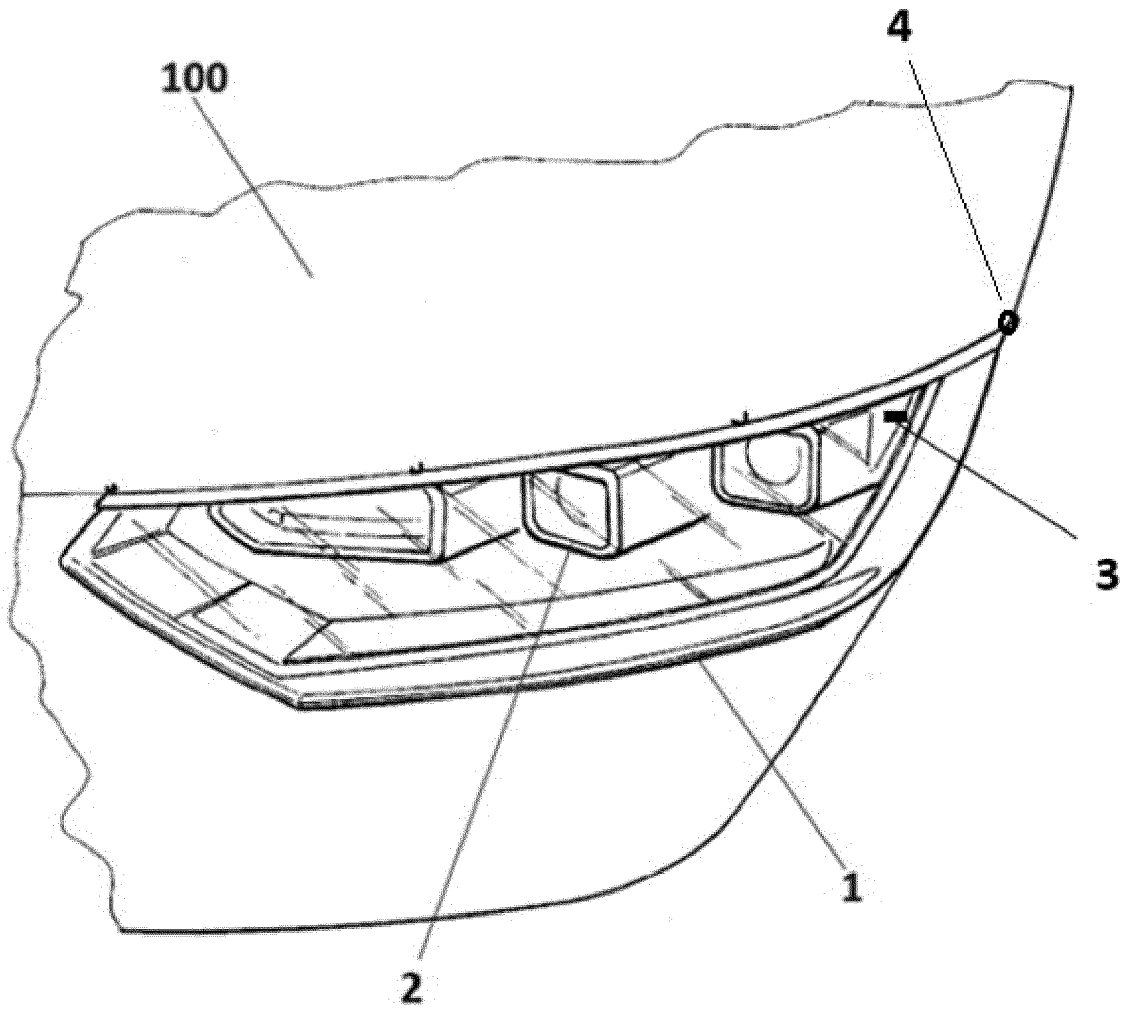


Fig. 1

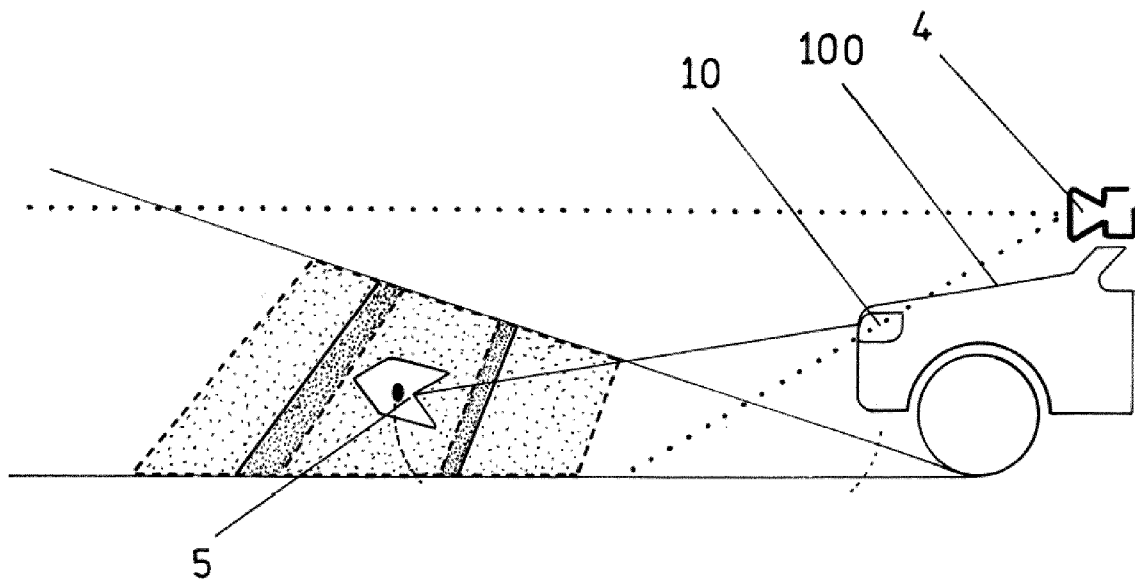


Fig. 2

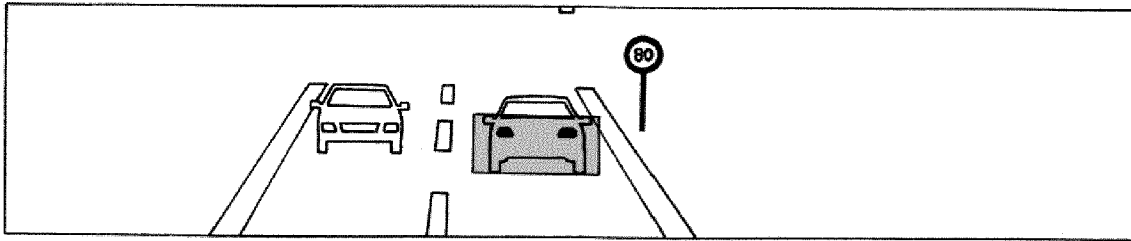


Fig. 3a

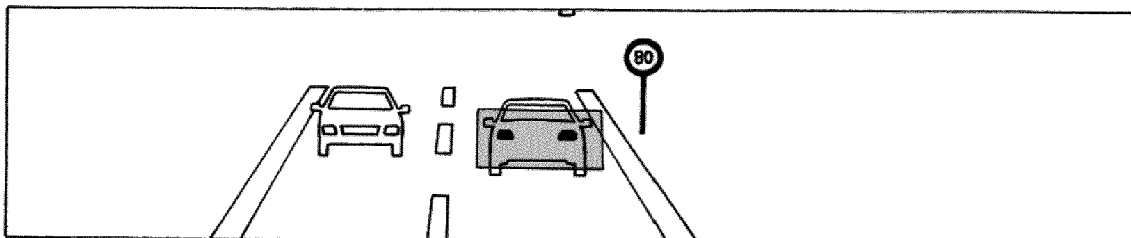


Fig. 3b

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/069911

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60Q1/10
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)
B60Q G01M

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	DE 10 2017 214950 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 28 February 2019 (2019-02-28) paragraphs [0009] - [0042]; figures 1, 2 -----	1-14
X	DE 10 2011 109440 A1 (DAIMLER AG [DE]) 19 April 2012 (2012-04-19) the whole document -----	1-5,7-14
X	EP 2 050 618 A2 (AUDI AG [DE]) 22 April 2009 (2009-04-22) paragraphs [0014] - [0059]; figures 1, 2 -----	1-4,7-14
X	DE 199 16 175 A1 (BOSCH GMBH ROBERT [DE]) 12 October 2000 (2000-10-12) paragraphs [0006] - [0029]; figures 1-4 ----- -/-	1-5,7-14



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2021/069911

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2008 011699 A1 (VOLKSWAGEN AG [DE]) 25 September 2008 (2008-09-25) paragraphs [0013] - [0084]; figures 1-5 -----	1-4,7-14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2021/069911

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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