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(54) Title: METHOD FOR CORRECTING A LIGHT PATTERN AND AUTOMOTIVE LIGHTING DEVICE

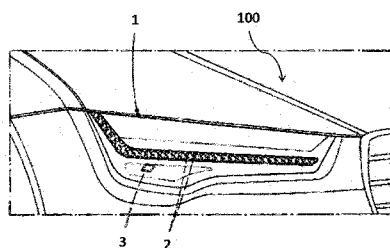


Fig. 1

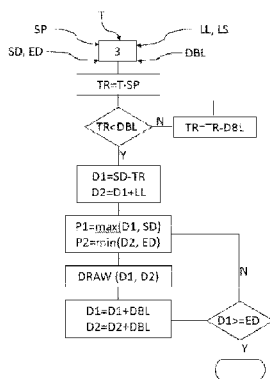


Fig. 4

(57) Abstract: The invention provides a method for correcting a first light pattern provided by a lighting device, wherein the first light pattern has a plurality of lane lines driven on the road. This method comprises the steps of sensing a lighting device speed and projecting a corrected light pattern. In this corrected light pattern, the position of the lane lines is different from the position of the lane lines in the first light pattern, and the difference depends on the lighting device speed. The invention also provides an automotive lighting device assembly with control means to perform the steps of this method.



METHOD FOR CORRECTING A LIGHT PATTERN AND AUTOMOTIVE LIGHTING DEVICE

TECHNICAL FIELD

This invention is related to the field of automotive lighting devices, and more particularly, to the way light patterns are managed.

STATE OF THE ART

Digital lighting devices are being increasingly adopted by car makers for middle and high market products.

Adaptive functions in lighting devices are usually focused on anti-glaring provisions. This is the main concern, since glaring is a very crucial point when providing a good quality high beam functionality.

However, there are some other possibilities to improve the drivers' experience, by adapting the light pattern to the current conditions of the vehicle.

SUMMARY OF THE INVENTION

The invention provides an alternative solution for improving the driver's visual experience by a method for correcting a light pattern according to claim 1 and an automotive lighting device according to claim 7. Preferred embodiments of the invention are defined in dependent claims.

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 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 include further elements, steps, etc.

In a first inventive aspect, the invention provides a method for correcting a first light pattern provided by an automotive lighting device, the first light pattern having a plurality of lane lines driven on the road, the method comprising the steps of

sensing a lighting device speed, and
projecting a corrected light pattern where the position of the lane lines is different from the position of the lane lines in the first light pattern, and the difference depends on the lighting device speed.

Since the automotive lighting device is usually mounted on an automotive vehicle, the lighting device speed is the same as the vehicle speed, which is sensed easily. The projection of a corrected light pattern which depends on the speed provides a better visual experience for the driver, since they perceive the real lane lines running towards them.

In some particular embodiments, the position of the lane lines in the corrected light pattern is translated towards the lighting device at the same speed as the lighting device speed.

Synchronizing the lighting device speed with the projection speed optimizes the driver's visual experience.

In some particular embodiments, the step of projecting a corrected light pattern is carried out with a predetermined frequency.

A predetermined frequency helps in the calculation of the corrected light pattern.

In some particular embodiments, the predetermined frequency is greater than 40 Hz, and particularly greater than 50 Hz.

A higher frequency is advantageous for the visual experience. If the vehicle drives at 35 m/s (which is, more or less, the maximum speed of a highway), it runs 0,8 m every 25 ms (which corresponds to 40 Hz). A higher refresh rate could be insufficient to provide a good visual experience for the driver.

In some particular embodiments, the corrected light pattern is projected between a start distance and an end distance.

The projection must be limited within a projection zone. A useful way of delimiting such a zone is between two distances, a start distance where the projection "starts", and is close to the lighting device, and an end distance, where the projection "finishes", and is far from the lighting device.

In some particular embodiments, before projecting the corrected light pattern, the method further comprises the steps of

- a) defining a line length and a line spacing;
 - b) defining a distance between lines variable, which is the sum of the line length and the line spacing;
 - c) sensing the time since the last corrected light pattern was projected;
 - d) defining a translation variable which represents the distance run by the lighting device since the last corrected light pattern was projected;
 - e) correcting, if necessary, the translation variable until it is lower than the distance between lines by subtracting a multiple of the distance between lines;
 - f) defining a first distance as the difference between the start distance and the translation variable;
 - g) defining a second distance as the sum of the first distance and the line length;
- and wherein the step of projecting the corrected light pattern comprises the steps of
- h) drawing a line from a first point, which is the maximum between the first distance and the start distance, to a second point, which is the minimum between the second distance and the end distance;
 - i) increasing the value of the first distance by summing the distance between lines variable and increasing the value of the second distance by summing the distance between lines variable; and
 - j) repeating steps h) and i) until the first distance is equal or greater than the end distance.

This algorithm ensures a correct projection of the corrected light pattern.

In a second inventive aspect, the invention provides an automotive lighting device comprising

- a matrix arrangement of solid-state light sources, intended to provide a light pattern;
- control means for accomplishing the steps of the method according to the first inventive aspect.

This lighting device provides the advantageous functionality of adapting the shape and focus of the light pattern depending on the vehicle speed.

In some particular embodiments, the matrix arrangement comprises at least 5000 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 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 life span of the illumination device. Some examples of these types of lighting comprise semiconductor light-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.

A matrix arrangement is a typical example for this method. The rows represent projecting distances and columns represent an angle interval. These distances and angles values depend on the resolution of the matrix arrangement. As a consequence, lane lines may be projected with a resolution enough to be perceived as running at the same speed as the vehicle.

BRIEF LIST OF DRAWINGS AND REFERENCE NUMBERS

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:

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

Figures 2a to 2e show the evolution of the projection of a light pattern before a method according to the invention takes place.

Figures 3a to 3d show the evolution of the projection of a light pattern when a method according to the invention is used.

Figure 4 shows an algorithm which is used in some embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

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.

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

This lighting device 1 is installed in an automotive vehicle 100 and comprises
a matrix arrangement of LEDs 2, intended to provide a light pattern;
control means 3 for controlling the intensity of each LED, to perform lighting functions and, particularly, to correct the light pattern depending on the vehicle speed.

This matrix configuration is a high-resolution module, having a resolution greater than 5000 pixels. However, no restriction is attached to the technology used for producing the projection modules.

A first example of this matrix configuration comprises a monolithic source. This monolithic source comprises a matrix of monolithic electroluminescent elements arranged in several columns by several rows. In a monolithic matrix, the electroluminescent elements can be grown from a common substrate and are electrically connected to be selectively activatable either individually or by a subset of electroluminescent elements. The substrate may be predominantly made of a semiconductor material. The substrate may comprise one or more other materials, for example non-semiconductors (metals and insulators). Thus, each electroluminescent element/group can form a light pixel and can therefore emit light when its/their material is supplied with electricity. The configuration of such a monolithic matrix allows the arrangement of selectively activatable pixels very close to each other, compared to conventional light-emitting diodes intended to be soldered to printed circuit boards. The monolithic matrix may comprise electroluminescent elements whose main dimension of height, measured perpendicularly to the common substrate, is substantially equal to one micrometre.

The monolithic matrix is coupled to the control centre so as to control the generation and/or the projection of a pixilated light beam by the matrix arrangement. The control centre is thus able to individually control the light emission of each pixel of the matrix arrangement.

Alternatively to what has been presented above, the matrix arrangement may comprise a main light source coupled to a matrix of mirrors. Thus, the pixelated light source is formed by the assembly of at least one main light source formed of at least one light emitting diode emitting light and an array of optoelectronic elements, for example a matrix of micro-mirrors, also known by the acronym DMD, for "Digital Micro-mirror Device", which directs the light rays from the main light source by reflection to a projection optical element. Where appropriate, an auxiliary optical element can collect the rays of at least one light source to focus and direct them to the surface of the micro-mirror array.

Each micro-mirror can pivot between two fixed positions, a first position in which the light rays are reflected towards the projection optical element, and a second position in which the light rays are reflected in a different direction from the projection optical element. The two fixed positions are oriented in the same manner for all the micro-mirrors and form, with respect to a reference plane supporting the matrix of micro-mirrors, a characteristic angle of the matrix of micro-mirrors defined in its specifications. Such an angle is generally less than 20° and may be usually about 12° . Thus, each micro-mirror reflecting a part of the light beams which are incident on the matrix of micro-mirrors forms an elementary emitter of the pixelated light source. The actuation and control of the change of position of the mirrors for selectively activating this elementary emitter to emit or not an elementary light beam is controlled by the control centre.

In different embodiments, the matrix arrangement may comprise a scanning laser system wherein a laser light source emits a laser beam towards a scanning element which is configured to explore the surface of a wavelength converter with the laser beam. An image of this surface is captured by the projection optical element.

The exploration of the scanning element may be performed at a speed sufficiently high so that the human eye does not perceive any displacement in the projected image.

The synchronized control of the ignition of the laser source and the scanning movement of the beam makes it possible to generate a matrix of elementary emitters that can be activated selectively at the surface of the wavelength converter element. The scanning means may

be a mobile micro-mirror for scanning the surface of the wavelength converter element by reflection of the laser beam. The micro-mirrors mentioned as scanning means are for example MEMS type, for "Micro-Electro-Mechanical Systems". However, the invention is not limited to such a scanning means and can use other kinds of scanning means, such as a series of mirrors arranged on a rotating element, the rotation of the element causing a scanning of the transmission surface by the laser beam.

Figures 2a to 2e show the evolution of this projection before a method according to the invention takes place. Projected lane lines 40 are moving with the vehicle 100 because they are static with respect of the vehicle, and this may cause visual discomfort in the driver if compared with road real lane lines 5.

Figures 3a to 3d show the evolution of this projection when a method according to the invention is used. Projected lane lines 4 are moving with respect of the vehicle 100, and this causes the effect of being static on the road, the same as the real lane lines 5.

To carry out this method, an algorithm such as the one shown in figure 4 is used in some embodiments of the invention.

First, the control means 3 is fed with some input values, which in this case will be the following

- the lighting device speed SP: since the lighting device is mounted on an automotive vehicle, the lighting device speed will correspond with the vehicle speed, which is measured easily;

- a start distance SD and an end distance ED: these distances represent the closest and farthest boundaries of the projection;

- a line length LL and a line spacing LS: these variables may be chosen by the car manufacturer, since they may adapt to different countries, where the lane lines may have different length, and the spacing between them may also vary;

- a distance between lines variable DBL, which is the sum of the line length and the line spacing;

- the time T since the last corrected light pattern was projected: this time may be given by the refresh rate, which may depend on the lighting device speed or may be fixed, depending on the car manufacturer's decision.

With these inputs, a translation variable TR is defined. This translation variable tries to represent the distance that the vehicle has run since the last time that a corrected light

pattern was projected. Accordingly, this transition variable is firstly defined as the product of the vehicle speed by the time since the last corrected light pattern was projected.

This translation variable is corrected, if necessary, by subtracting a multiple of the distance between lines, until the final value of the translation variable is an amount lower than the distance between lines. This is done because the projection of lines is cyclical, and the interest about the translation variable resides on measuring the distance between the start distance and the first lane line.

After that, a first distance D1 and a second distance D2 are defined. The first distance D1 is the difference between the start distance SD and the translation variable TR. It represents where the first line should start to be drawn. The second distance D2 is the sum of the first distance D1 and the line length LL. It represents where the first line should finish.

Then, a cyclical process of drawing lines is carried out: a line is drawn from the first point P1 to the second point P2. The first point P1 is the maximum between the first distance D1 and the start distance SD, and the second point P2 is the minimum between the second distance D2 and the end distance ED. This is thus defined because there is no drawing closer than the start distance and there is no drawing beyond the end distance. After the drawing of the first line, the variables of first distance D1 and second distance D2 are shifted by the value of the distance between lines variable and the cyclical process continues until the first distance is equal or greater than the end distance.

As a consequence, projected lines according to this corrected light pattern intend to be "fixed on the road", since the speed of travelling of the projection with respect of the lighting device is the same and opposite to the speed of the vehicle with respect of the road where the lines are projected.

CLAIMS

1.- Method for correcting a first light pattern provided by a lighting device (1), the first light pattern having a plurality of lane lines (40) driven on the road, the method comprising the steps of

sensing a lighting device speed (SP), and

projecting a corrected light pattern where the position of the lane lines (4) is different from the position of the lane lines (40) in the first light pattern, and the difference depends on the lighting device speed (SP).

2.- Method according to claim 1, wherein the position of the lane lines (4) in the corrected light pattern is translated towards the lighting device (1) at the same speed as the lighting device speed (SP).

3.- Method according to any of the preceding claims, wherein the step of projecting a corrected light pattern is carried out with a predetermined frequency.

4.- Method according to claim 3, wherein the predetermined frequency is lower than 100 Hz, and particularly equal or lower than 50 Hz.

5.- Method according to any of the preceding claims, wherein the corrected light pattern is projected between a start distance (SD) and an end distance (ED).

6.- Method according to claim 5 when it depends on claims 3 or 4, wherein, before projecting the corrected light pattern, the method further comprises the steps of

a) defining a line length (LL) and a line spacing (LS);

b) defining a distance between lines variable (DBL), which is the sum of the line length (LL) and the line spacing (LS);

c) sensing the time (T) since the last corrected light pattern was projected;

d) defining a translation variable (TR) which represents the distance run by the lighting device (1) since the last corrected light pattern was projected;

e) correcting, if necessary, the translation variable (TR) until it is lower than the distance between lines (DBL) by subtracting a multiple of the distance between lines;

f) defining a first distance (D1) as the difference between the start distance (SD) and the translation variable (TR);

g) defining a second distance (D2) as the sum of the first distance (D1) and the line length (LL);

and wherein the step of projecting the corrected light pattern comprises the steps of

h) drawing a line from a first point (P1), which is the maximum between the first distance (D1) and the start distance (SD), to a second point (P2), which is the minimum between the second distance (D2) and the end distance (ED);

i) increasing the value of the first distance (D1) by summing the distance between lines variable (DBL) and increasing the value of the second distance by summing the distance between lines variable (DBL); and

j) repeating steps h) and i) until the first distance (D1) is equal or greater than the end distance (ED).

7.- Automotive lighting device (1) comprising

a matrix arrangement of solid-state light sources (2), intended to provide a light pattern;

control means (3) for accomplishing the steps of the method according to any of the preceding claims.

8.- Automotive lighting device (1) according to claim 7, wherein the matrix arrangement comprises at least 5000 solid-state light sources (2).

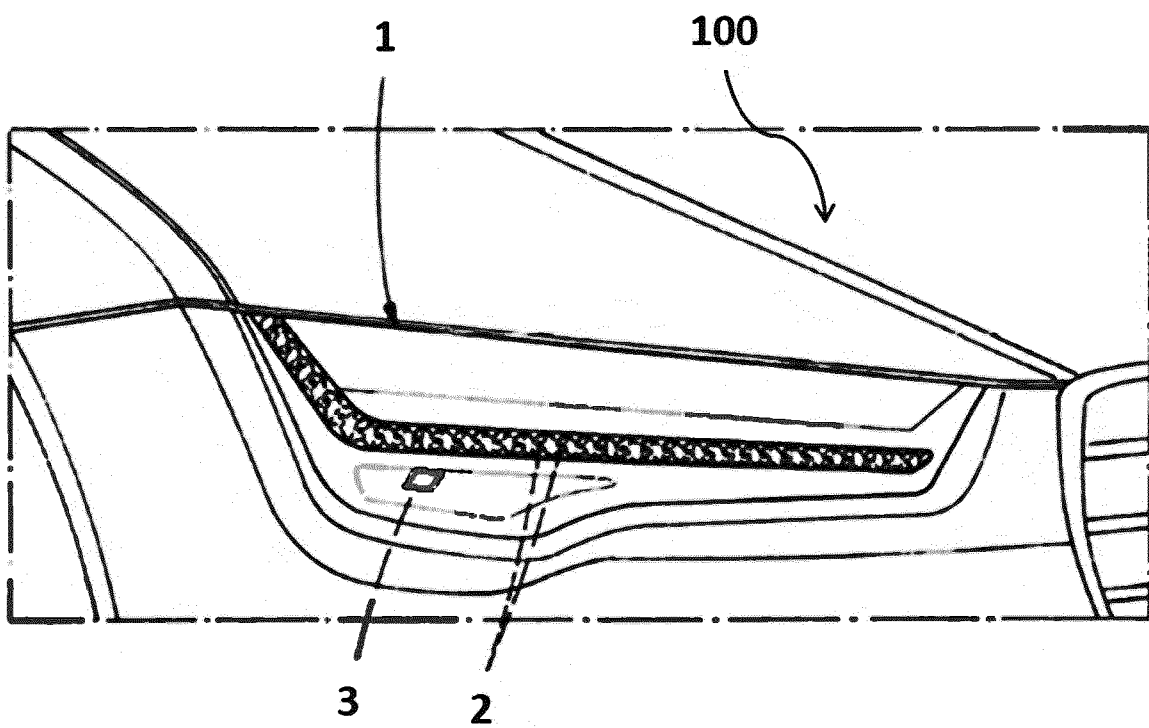


Fig. 1

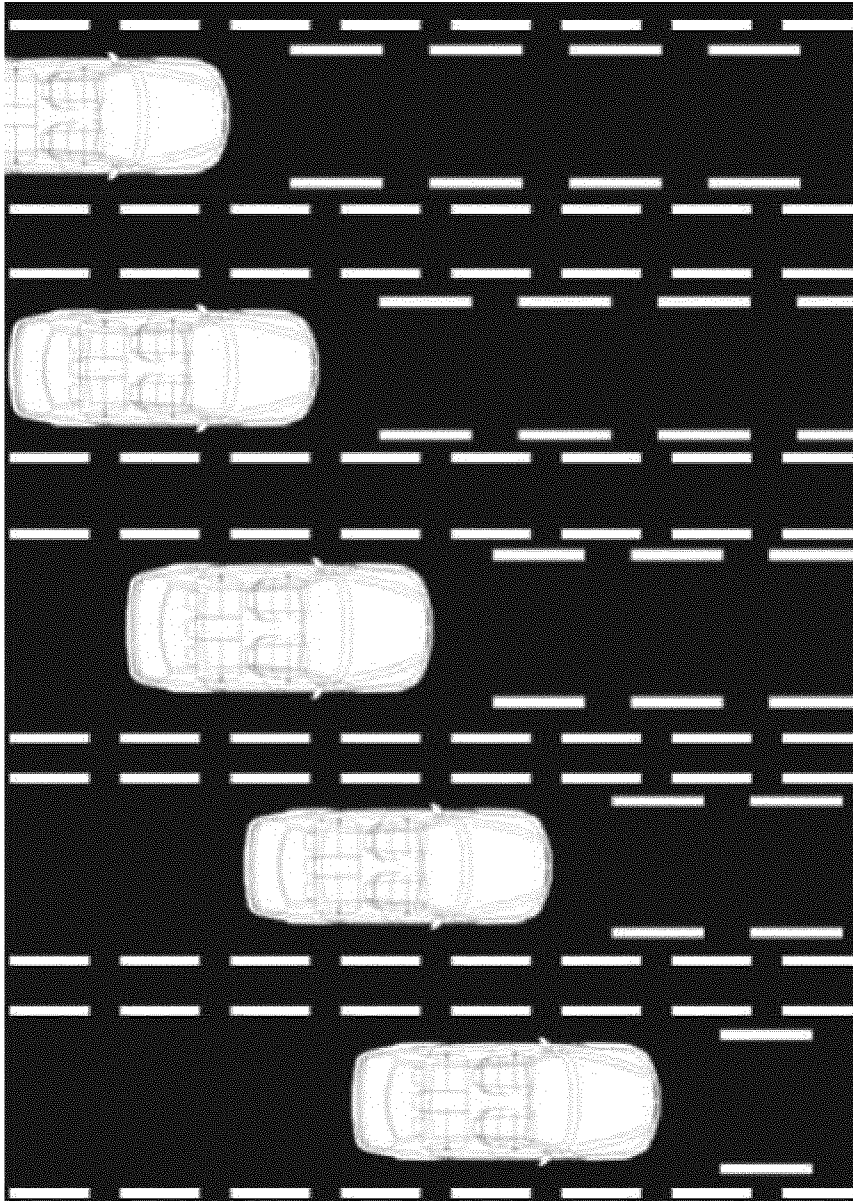


Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Fig. 2e

Fig. 2a – 2e

Fig 3a – 3d same with the other animation

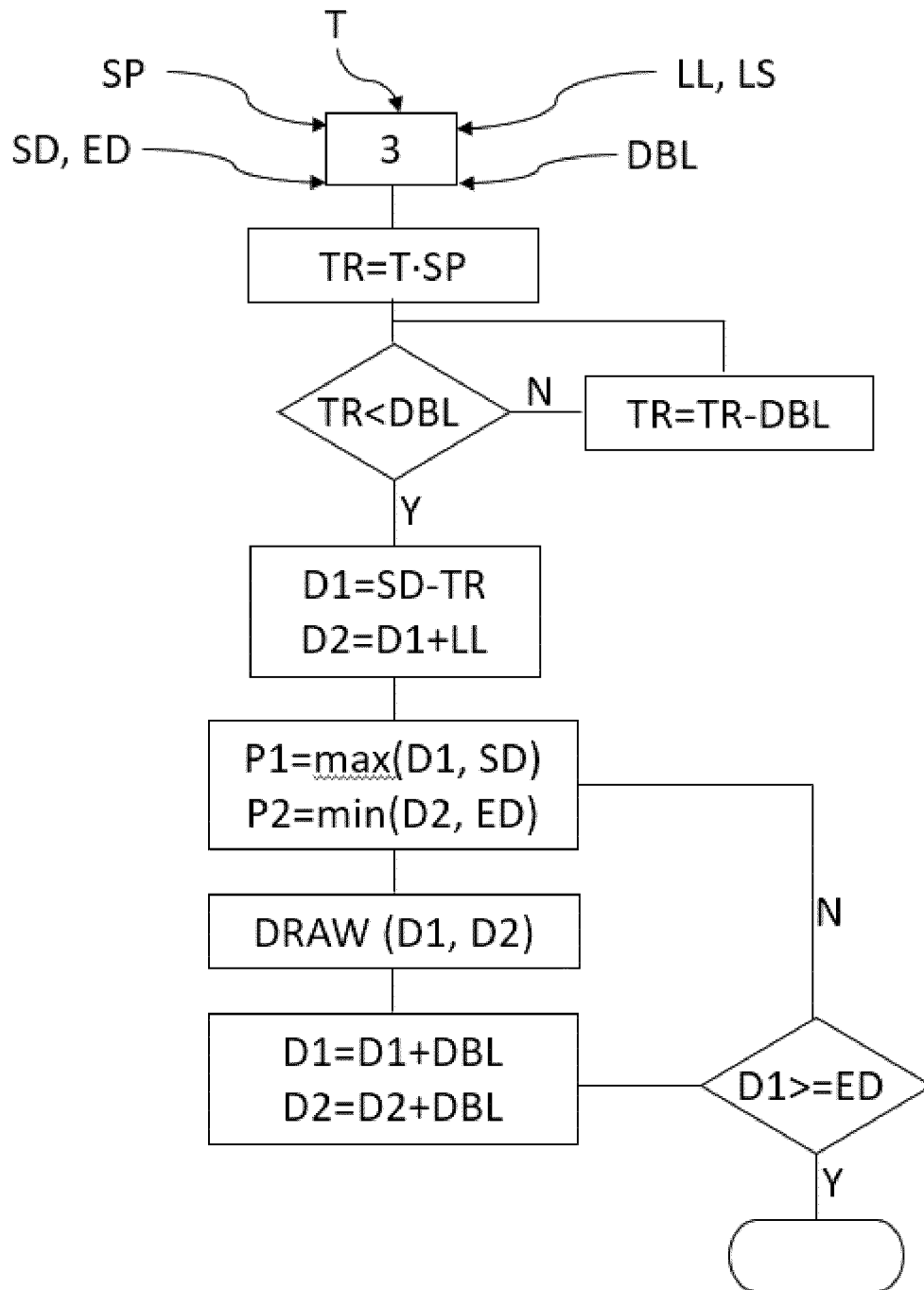


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052369

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60Q1/50 B60Q9/00
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

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

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Y	paragraphs [0001], [0013], [0024], [0025], [0030], [0055] - [0058], [0135] - [0152]; figures 1-5,10,12-18,23A-23C -----	3,4,8
Y	DE 10 2012 003158 A1 (DAIMLER AG [DE]) 22 August 2013 (2013-08-22)	3,4,8
A	paragraphs [0001], [0012], [0018], [0019], [0024], [0025], [0040]; figures 1-3 -----	1
X	EP 3 401 161 A2 (STANLEY ELECTRIC CO LTD [JP]) 14 November 2018 (2018-11-14) paragraphs [0001], [0004], [0005], [0009] - [0012], [0048] - [0055], [0060], [0071] - [0097]; figures 1-7C ----- -/-	1,5,7,8



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

24 February 2020

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05/03/2020

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052369

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3 428 511 A1 (STANLEY ELECTRIC CO LTD [JP]) 16 January 2019 (2019-01-16) paragraphs [0001], [0002], [0011], [0013] - [0016], [0027] - [0033], [0040], [0041], [0049] - [0083]; figures 1-4A,5 -----	1,5,7,8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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