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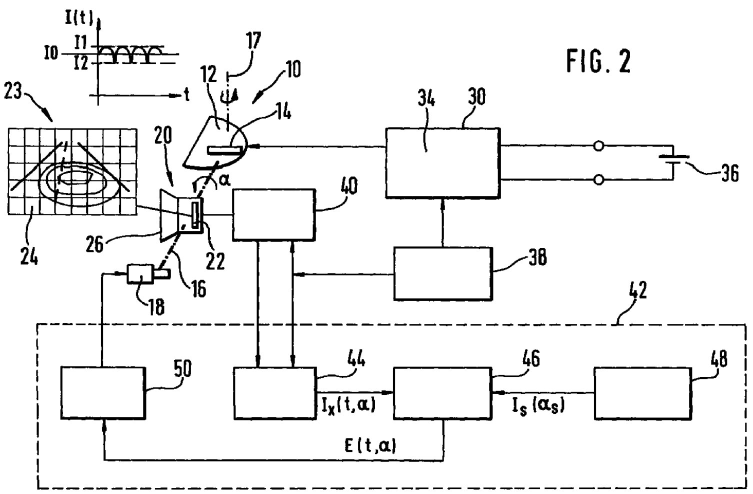
(54) **Direction adjustment device for light beam emitted by at least one vehicle headlight**

(57) The headlight (10) includes at least one light source (14) which is operated at least occasionally so as to allow temporal variation of the intensity of the light emitted therefrom. For example, the apparatus is to control the illumination range of the light beam emitted by the headlight (10) and includes a sensor device (20) which detects an illumination situation in front of the vehicle in terms of the light reflected by the roadway. The sensor device (20) is connected with an input unit (44) of an evaluation device (42) which processes the illumination situation detected by the sensor device (20) regarding the light portion containing the temporally varying intensity, and this light portion is supplied to a processing unit (46) which compares the current illumination situation with a given target illumination situation with correctly adjusted illumination range. If there exists a difference, the processing unit generates an output signal to actuate an adjustment device (18) associated with the headlight (10) which adjusts the inclination of the headlight until the correct illumination range is set.

FIG. 2



Specification

Background Art

[0001] The invention is based on an apparatus for adjusting the direction of a light beam emitted by at least one headlight of a vehicle according to the preamble of claim 1.

[0002] Such an apparatus is known from DE 41 22 531 A1 in the form of an apparatus for controlling the illumination range of the light beam emitted by at least one headlight of a vehicle. This apparatus includes an adjustment device associated with the headlight by means of which the illumination range may be adjusted. Additionally, the apparatus includes at least one optoelectronic sensor device which detects an illumination situation in form of the light emitted by the headlight and reflected by the roadway in front of the vehicle. Finally, the apparatus also includes an evaluation device connected to the sensor device and the adjustment device which compares the current illumination situation detected by the sensor device with stored data of a target illumination situation. If there exists a difference between the illumination situation currently detected by the sensor device and the target illumination situation according to the stored data, the evaluation device controls the adjustment device such that the difference is eliminated or at least minimized. However, the sensor device not only detects the light emitted by the headlight of the vehicle and reflected by the roadway, but also light originating from other light sources and reflected by the roadway. For example, this light may be emitted by headlights of other vehicles or by street lighting and leads to inaccuracies of the adjustment of the illumination range of the headlight.

Advantages of the Invention

[0003] The apparatus for adjusting the direction of the light beam emitted by at least one headlight according to the invention has the advantage, that the light emitted by the headlight of the vehicle differs in terms of its temporally varying nature from the light originating from other light sources, and thus the illumination situation detected by the at least one sensor device is evaluated specifically regarding this portion of the light. The adjustment of the direction of the light beam emitted by the headlight may thus be performed with high accuracy, because it is not affected by light originating from other light sources.

[0004] The dependent claims specify advantageous embodiments and developments of the apparatus according to the invention for adjusting the direction of the light beam emitted by at least one headlight. The embodiment of claim 3 allows the intensity of the light emitted by the light source to be time modulated in a simple manner. The embodiment of claim 8 ensures that the time modulated light emitted by the light source is at least processed in an essentially targeted manner.

Figures

[0005] Several exemplary embodiments of the invention are shown in the drawings and discussed in detail in the description below. Figure 1 shows a vehicle having headlights illuminating the roadway in front of the vehicle, Figure 2 shows a schematic diagram of an apparatus to control the illumination range of the headlights of the vehicle, Figure 3 shows the intensity of a constant light portion emitted by a light source of a headlight as a function of time, Figure 4 shows the intensity of the variable light portion emitted by the light source as a function of time, and Figure 5 shows the superposition of the constant and the variable light portions emitted by the light source as a function of time.

Description of Exemplary Embodiments

[0006] A vehicle depicted in Figure 1, which is preferably a motor vehicle, includes in known fashion two low beam headlights 10 at its front end that are attached to the body of the vehicle. The low beam headlights 10 may only serve to generate low beam light or may be embodied as combined low beam and high beam headlights for selectively generating low beam light or high beam light. Each low beam headlight 10 includes a reflector 12 into which at least one light source 14 is inserted. The low beam headlight 10 as a whole, or at least its reflector 12, can be pivoted about an axis 16 extending approximately horizontally and/or an axis 17 extending approximately vertically. By pivoting the low beam headlight 10 or its reflector 12, respectively, about the horizontal axis 16 the direction of the light beam emitted therefrom can be modified in a vertical plane and thus the illumination range of the light beam emitted by the low beam headlight can be modified. By pivoting the low beam headlight 10 or its reflector 12, respectively, about the vertical axis 17 the direction of the light beam emitted therefrom can be modified in a horizontal plane and thus the path of the light beam can be modified in a lateral direction. Thereby, for example, the direction of the light beam emitted by the low beam headlight 10 may be adapted to the path of the roadway in front of the vehicle, in particular when cornering, to achieve sufficient illumination of the roadway.

[0007] The following is an exemplary description of the adjustment of the direction of the light beam emitted by the low beam headlight 10 in a vertical plane and thus the adjustment of the illumination range of the light beam emitted by the low beam headlight. Each low beam headlight 10 has an associated adjustment device 18 by means of which the entire headlight or at least its reflector 12 can be pivoted about the axis 16. Preferably, the adjustment devices 18 may include an electric motor as a drive which moves an adjustment member hinged to the headlight 10 or its reflector 12 via a gear. Alternatively, the adjustment devices 18 may also be actuated by hydraulic, pneumatic or electromagnetic means.

[0008] In operation, the low beam headlights 10 emit light beams which illuminate the area in front of the vehicle. Figure 1 illustrates the light beams by means of a plurality of lines of equal illuminance, so-called isolux lines 20. The light beams have a greater range on the side of their own travel, in the depicted embodiment for right-hand traffic the right side of traffic, than on the side of oncoming traffic. Due to the arrangement of the low beam headlights 10 on the vehicle body, the inclination of the low beam headlights 10 relative to the roadway changes with the inclination of the vehicle body. A change in inclination of the vehicle body occurs, for example, with changing vehicle load, during acceleration or braking maneuvers of the vehicle, or when traversing bumps in the roadway. The change in inclination of the low beam headlights 10 also leads to a change of their range of illumination, in the sense that the range of illumination increases in case of deflection of the rear axle and the range of illumination decreases in case of deflection of the front axle. An increase in the range of illumination leads to blinding of oncoming traffic, whereas a decrease in the range of illumination leads to a decrease of the visibility range of the vehicle operator. In order to compensate for the change in illumination range of the low beam headlights 10 caused by the change in inclination of the vehicle body, a device for controlling the range of illumination is provided which keeps the range of illumination at least approximately constant and which is discussed in more detail below.

[0009] Figure 2 shows a simplified schematic of the device for controlling the illumination range. The device includes at least one optoelectronic sensor device 20. Only one common sensor device 20 may be provided for both low beam headlights 10, or one sensor device 20 each may be provided for each low beam headlight 10. The sensor device 20 detects the illumination situation in front of the vehicle in terms of the light reflected by the roadway in front of the vehicle. The sensor device 20 includes a plurality of discrete light-sensitive elements 22 that are, for example, be embodied as photo cells, photo diodes, photo transistors, or CCD (charge-coupled device). The light-sensitive elements 22 are arranged in a matrix-like or linearly distributed fashion. The sensor device 20 may also include only one light-sensitive element which has a one-dimensional linear extension or a two-dimensional planar extension, wherein the light impinging on sub-areas of the element may be detected separately for each sub-area. The light-sensitive element may here be embodied as a PSD (photo sensing device). The image 23 of the illumination situation is divided into a plurality of sub-areas 24 in grid-like manner, wherein the sensor device 20 detects the illuminance present in each sub-area 24. Additionally, the sensor device 20 includes imaging optics, for example in form of a lens 26 which images incident light onto the light-sensitive element(s) 22. The illuminances detected for the various sub-areas 24 may be read out of the sensor device 20 in chronological sequence one after the other for the light-sensitive elements 22 associated with these sub-areas 24. If the light-sensitive elements 22 are arranged linearly, they are moved to determine the illuminances in each of the sub-areas 24 in order to allow all sub-areas 24 of the image 23 to be recorded. Thereby the incident light may be detected in each position of the elements 22 for sub-areas 24 arranged in a row or a column, and then the elements 22 are moved further, so that the incident light of sub-areas 24 arranged in an adjacent row or column may be detected. The sensor device 20 is preferably positioned at the low beam headlight 10 such that the device can be pivoted together with the low beam headlight 10 or its reflector 12 about the axis 16 by means of the adjustment device 18.

[0010] The light source 14 of the low beam headlight 10 is preferably a discharge lamp, for the operation of which an electric ballast 30 is provided. The ballast 30 includes an ignition device which generates the high voltage necessary for starting the discharge lamp 14. In addition, the ballast 30 includes an operating device 32 for continuous operation of the discharge lamp 14, including, but not restricted to a converter 34 for generating alternating current and alternating voltage, which are supplied to the discharge lamp 14, from the direct current and the direct voltage supplied by the battery 36 on board of the vehicle.

[0011] Connected to the operating device 32, in particular to its converter 34, is a control device 38 which controls the flow of the alternating current and the alternating voltage supplied to the discharge lamp 14 by the converter 34 at least intermittently. The flow of the electric current and voltage or the electric power, respectively, supplied to the discharge lamp 14 is temporally varied by the control device 38 at least intermittently, such that the intensity of the light emitted by the discharge lamp 14 varies correspondingly as a function of time in characteristic manner as specified by the control device 38. Preferably, the converter 34 supplies an alternating current or an alternating voltage with a specific fundamental frequency and a specific fundamental amplitude to the discharge lamp 14 as suitable for stable operation of the discharge lamp 14. The control device 38 then varies the alternating current and/or the alternating voltage supplied to the discharge lamp 14 over time with one or more of a specific frequency, amplitude, and phase based on the fundamental frequency and the fundamental amplitude. Here, the fundamental frequency and the fundamental amplitude are preferably larger than the temporal variation of the frequency and amplitude of the alternating current and/or the alternating voltage caused by the control device 38.

[0012] Figure 3 shows the intensity I(t) of the light emitted by the discharge lamp 14 as a function of time, if the discharge lamp 14 is supplied with an alternating current and/or an alternating voltage with constant fundamental frequency and constant fundamental amplitude. Here, the intensity I(t) varies according to the fundamental frequency of the current or the voltage around an average value I0 which is determined by the amplitude of the supplied current or voltage, respectively. Figure 4 shows the intensity I(t) of the light emitted by the discharge lamp 14 as a function of time, with a temporal variation caused by the control device 38. The intensity I(t) according to Figure 4 varies with a frequency that is lower than the fundamental frequency. Figure 5 shows the intensity I(t) as a function of time with greater temporal resolution, wherein the variations in intensity I(t) with the fundamental frequency f0 and the frequency f1 are superimposed over one another. Figure 5 depicts the period t0 of the fundamental frequency f0 and the period t1 of the frequency t1 caused by the control device 38. During one period t1 of the frequency f1 there is a plurality of periods t0 of the fundamental frequency f0.

[0013] The amplitude Imax of the intensity I(t) is varied by the control device 38 with the frequency f1 between a first, higher value I1 and a second, lower value I2. Between the two values I1 and I2, the intensity I(t) may fall to zero for very short time periods. The frequency f1 of the temporal variation of the intensity I(t) caused by the control device 38 may be constant or vary over time. The difference of the amplitudes I1 and I2 may also be constant or vary over time. In order to achieve a characteristic time-dependent variation of the intensity I(t) of the light emitted by the discharge lamp 14, for example, the control device 38 may also cause a phase modulation of the alternating current and the alternating voltage that is supplied to the discharge lamp 14.

[0014] A clock device 40 is connected to the control device 38 and also connected to the sensor device 20. The clock device 40 synchronizes the operation of the sensor device 20 with the temporal variation of the characteristic of the light emitted by the discharge lamp 14, that is, the sensor device 20 detects the illumination situation in front of the vehicle during the time periods, during which the control device 38 modulates the intensity of the light emitted by the discharge lamp 14. The sensor device 20 is operated synchronized with the time varying characteristic of the intensity of the light emitted by the discharge lamp 14 at each respective point in time. The clock device 40 may also control the movement of the linearly arranged light-sensitive element(s) 22 of the sensor device 20 that is necessary in order to detect the incident light in all sub-areas 24 of the image 23 of the illumination situation.

[0015] The sensor device 20 is connected to an evaluation device 42 which will be described below. The evaluation device 42 includes an input unit 44 which is connected to the sensor device 20 and the clock device 40. The input unit 44 is in turn connected to a processing unit 46. The input unit 44 transfers the signals provided by the sensor device 20 synchronized with the temporal variation of the intensity of the light emitted by the discharge lamp 14 caused by the control device 38 to the processing unit 46. The synchronization of the transfer of the signals from the sensor device 20 to the processing unit 46 by the input unit 44 is ensured by means of its connection to the clock device 40. Transferring the signals of the sensor device 20 synchronized with the temporal variation of the intensity of the light emitted by the discharge lamp 14 achieves that the portion of the light detected by the sensor device 20 originating from the discharge lamp 14 is amplified and substantially only this light portion is processed. External light originating from other light sources, for example from headlights of other vehicles or from street lighting, is not synchronized or statistically correlated, respectively, with the temporal variation of the intensity of the light emitted by the discharge lamp 14 and is thus filtered out by the input unit 44 and not transferred or only transferred to a small extent to the processing unit 46. The input unit 44 thus transfers an image of the illumination situation in front of the vehicle to the processing unit 46, which image substantially only contains the portion of the illumination which is caused by the light originating from the headlight 10.

[0016] In addition to the input unit 44, the processing unit 46 is connected to a memory unit 48 as well which stores data about at least one image of the illumination situation in front of the vehicle as is present when the illumination range of the headlight 10 is set correctly. In the sub-areas 24 of the image 23 of the illumination situation in front of the vehicle certain illuminances are present when the illumination range is set correctly, and a certain distribution of illuminances over the various sub-areas 24 is present. The memory unit 48 may store data of various images of the illumination situation in front of the vehicle as they are detected by the sensor device 20, for example, under different weather conditions, in case of dry or wet roadways or on different road surfaces. The data stored in the memory unit 48 are determined under actual illumination of the roadway in front of the vehicle by means of the headlight 10 and via detection of the illumination situation by the sensor device 20.

[0017] The processing unit 46 compares the current data $Ix(t,\alpha)$, transferred to it by the input unit 44, of the image of the illumination situation generated by the sensor device 20 with the data $Is(\alpha s)$ present in the memory unit 48. The current data Ix depend on time t and the inclination of the headlight 10 or of its reflector 12, respectively, relative to the roadway and the data Is represent a target value. When comparing the data, the processing unit 46 forms the difference $E(t,\alpha) = Is(\alpha s) - Ix(t,\alpha)$, which is a measure of the deviation of the current illumination range from the target illumination range. The difference $E(t,\alpha)$ depends on the angle of inclination $\alpha(t)$ of the headlight 10 relative to the roadway which in turn is a function of time. In order to determine the difference $E(t,\alpha)$, the processing unit 46 applies known correlation methods.

[0018] The processing unit 46 generates an output signal which drives the adjustment device 18 of the headlight 10 via a correction unit 50. The output signal of the processing unit 46 is such that the adjustment device 18 is controlled such that the inclination α of the headlight 10 or its reflector 12, respectively, is changed such that the light beam emitted by the headlight 10 has the given target illumination range and thus the difference $E(t,\alpha)$ determined by the processing unit 46 becomes zero or is at least minimized. When the headlight 10 or its reflector 12, respectively, pivots, the sensor device 20 pivots with it about the axis 16 as well.

[0019] The correction unit 50 may be supplied with other signals other than the output signal of the processing unit 46, for example with one or more of signals about weather conditions such as rain or fog, the velocity of the vehicle, the acceleration of the vehicle, the speed of the motor of the vehicle, and signals of a controller of an automatic transmission of the vehicle. The correction unit 50 checks the output signal of the processing unit 46 for plausibility, that is, whether the output signal for driving the adjustment device 18 can lead to a correct adjustment of the illumination range considering the information available to the correction unit 50 due to the additional signals. The correction unit 50 may also estimate a reliability of the output signal of the processing unit 46 considering the available additional information, for example the weather conditions, and, depending on the reliability, correct the signal. For this, the correction unit 50 may employ, for example, methods involving fuzzy logic.

[0020] The time variation of the intensity of the light emitted by the discharge lamp 14 caused by the control device 38 is preferably in terms of amplitude and frequency such that it is not observable by the human eye and thus the illumination of the roadway for the vehicle operator is not compromised. It may be provided at each low beam headlight 10 that the intensity of the light emitted by its light source 14 is modulated and that a sensor device 20 and an evaluation device 42 is associated with each low beam headlight 10, wherein the illumination range of each of the two low beam headlights may be

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