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(54) Title: INTELLIGENT BICYCLE LIGHTING SYSTEM FOR OPTIMAL ROAD VISIBILITY

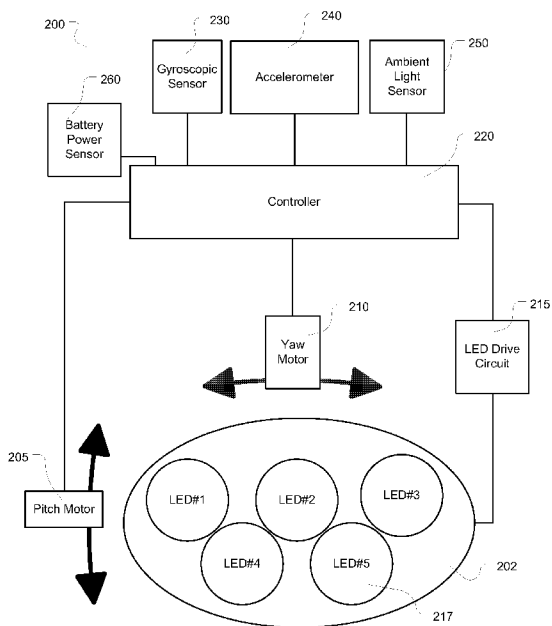


FIG. 2

(57) Abstract: The present disclosure extends to methods, systems, and apparatuses for improved cycling illumination which comprises a lighting element, a plurality of motors for adjusting the pitch and yaw of the light-ing element, a drive circuit for driving the light element to produce a var-ied flashing pattern and intensity.

INTELLIGENT BICYCLE LIGHTING SYSTEM FOR OPTIMAL ROAD VISIBILITY

TECHNICAL FIELD

[0001] The disclosure relates generally to intelligent lighting methods, systems, and apparatuses for cycling and improved cycling illumination for optimal road visibility.

BACKGROUND

[0002] In more densely populated cities where traffic has become heavy, bicycles provide an alternative mode of transportation and are becoming a preferred mode of personal mobility in the urban context. Typically, bicycle lights use a lot of power and quite frequently require additional accessory power to maintain a charge. This can be an annoyance for the bicycle rider who must keep charging or replacing the light's battery. Another common approach is to use a wheel hub dynamo to generate power to charge the light while riding, but dynamos tend to be expensive, bulky and require additional installation. In addition, current bicycle lights do not adjust the brightness based on the ambient riding condition and are often designed to be relatively dim for power saving purposes. This is potentially hazardous when riding on roads with poor lighting. However, while riding on well-lit streets, excessively bright bicycle lights are also not ideal and may affect the vision of nearby car drivers. On poorly-lit roads, a bicycle light is extremely critical for the cyclist's own ability to see, as well as be seen by nearby traffic. When riding on dark, winding roads, cyclists need to be able to see ahead clearly into the upcoming turn so as to be aware of any oncoming traffic.

[0003] The disclosed methods and systems herein, provide efficient and effective bicycle lighting. The disclosed methods, features, and systems that improves the safety of cycling as a growing mainstream mode of transportation.

[0004] The features and advantages of the disclosure will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by the practice of the disclosure without undue experimentation. The features and advantages of the disclosure may be realized and obtained by means of the features, parts, instruments and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Non-limiting and non-exhaustive implementations of the present disclosure are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified. Advantages of the present disclosure will become better understood with regard to the following description and accompanying drawings where:

[0006] FIG. 1 illustrates an overhead view of how an optimized bicycle headlight illuminates a cyclist's path while riding on a road;

[0007] FIG. 2 illustrates a schematic of a bicycle headlight comprising a light element driven by a drive circuit that is responsive to operational signals generated by a controller;

[0008] FIG. 3 illustrates a computing hardware schematic 300 of an implementation of the headlight system 200 in accordance to the present disclosure; and

[0009] FIG. 4 illustrates a method for controlling a bicycle headlight for providing improved illumination in dynamic environments.

DETAILED DESCRIPTION

[0010] The present disclosure extends to methods, systems, and cycling products for providing optimized illumination during dynamic and demanding conditions. In the following description of the present disclosure, reference is made to the accompanying drawings, which form a part hereof, and in which is shown by way of illustration specific implementations in which the disclosure may be practiced. It is understood that other implementations may be utilized and structural changes may be made without departing from the scope of the present disclosure.

[0011] The disclosure provides an intelligent lighting system that adjusts the lighting angle and brightness of a bicycle light to improve visibility. FIG. 1 illustrates an overhead view of how an optimized bicycle headlight illuminates a cyclist's path while riding on a road.

Schematically, a bicycle headlight 100 may be mounted to a bicycle 105 that is being ridden by a cyclist 110 along a curved road 115 (or cycling path). As can be seen in the figure, an obstacle 120 is on the road 115 in the path of the cyclist 110. In the figure, the original illumination area of the light beam produced by the bicycle headlight 100 is illustrated as an oval labeled "A" and adjusted illumination areas are shown as dashed line oval labeled A+Yaw, A+Pitch, and A+Pitch+Yaw. In an implementation, the bicycle headlight 100 may be adjusted and driven to move physically by two motors. The first motor 130 may be configured to move the bicycle headlight 100 horizontally to adjust the yaw, while a second motor 140 may be configured to move the bicycle headlight 100 vertically to adjust pitch. Additionally, the first and second motors may be driven in a manner that is responsive to sensors that are electronically connected to a controller 155 within the headlight 100.

[0012] As illustrated in the figure, the pitch of the headlight 100 may be adjusted to produce the illumination pattern labeled A+Pitch, which would be better as speed changes. Although the pitch adjusted illumination area A+Pitch produces an illumination pattern that is further out from the cyclist 110 thereby providing increased awareness, it does not fall upon the obstacle 120. Accordingly, it would be advantageous to also adjust the yaw of the headlight 100 so that the illumination area may be moved side to side horizontally.

[0013] Furthermore, as illustrated in the figure, the pitch of the headlight 100 may be adjusted to produce the illumination pattern labeled A+Yaw, which would be advantageous when turning. The yaw adjusted illumination area A+Yaw produces an illumination area that illuminates more peripheral areas relative to the cyclist 110, thereby providing increased awareness while turning. However, the A+Yaw illumination alone would also fail to fall upon the obstacle 120. Accordingly, it would be advantageous to adjust both the yaw and pitch of the headlight 100 so that the illumination area may be moved both horizontally and vertically at the same time.

[0014] Additionally, as illustrated in the figure, the disclosed system may dynamically adjust the horizontal yaw angle as the cyclist 110 starts to turn, so that the road leading into the upcoming turn may be well-lit and safely anticipated by the cyclist. As further illustrated in FIG. 1, an improved illumination area may be created by adjusting the yaw and pitch of the headlight 100 simultaneously. Such an illumination area is shown by the oval labeled A+Pitch+Yaw, which does fall on the obstacle, thereby providing increased awareness of the upcoming obstacle for the cyclist 110.

[0015] Consistent with FIG. 1, an implementation of the headlight 100 may comprise an ambient light sensor 150 that is configured to sense the ambient light. In such an

implementation, the output of the light element may be adjusted by a control unit 155 in response to the data received from the ambient light sensor 150. Accordingly, the light element may be adjusted such that the headlight 100 illuminates more brightly or less brightly depending upon the data received from the ambient light sensor 150. The disclosed system may also dynamically adjust the pitch angle of the bicycle headlight 100 when the cyclist 110 is riding on very dark roads 115 to provide sufficient lighting to clearly see potential obstructions on the road 115 that are close in front of the cyclist 110 as well as a broader view of the upcoming road ahead. For example, the disclosed system may automatically adjust the brightness, and intensity of the bicycle light responsive to the sensed environmental conditions. As can be seen in the figure, the road 115 may be lit by street lamps 160 and 170, each producing an illuminated area 161 and 171, respectively. As the cyclist 110 rides through the illumination areas 161, 171 the headlight 100 may automatically adjust its output to compensate for the dynamic lighting conditions. These adjustments may occur at any frequency such that the cyclist 110 is provided with more consistent light. For example, the sensing of ambient light and adjustments in illumination may be made in the range of 1 hertz to 100 hertz.

[0016] In an implementation, the system is also capable of flashing the bicycle light 100 at different frequencies, based on environmental conditions, to make the cyclist more visible to differing levels of surrounding traffic. For example, an embodiment of the disclosed system may also be set to flash at some frequency to provide more visibility for surrounding car drivers and pedestrians. The determination of the frequency of the flashing of the bicycle light 100 may be based on a combination of the ambient lighting conditions and the bicycle speed by integrating a value from an accelerometer as discussed more fully herein. The ambient lighting conditions may be obtained from a value from the ambient light sensor 150. If the system determines that

there is enough ambient lighting based on the value from the ambient light sensor 150, then the controller 155 may increase the flashing frequency to raise the awareness of the presence of the bicycle, while reducing the brightness of the bicycle light 100. At the same time, the system may also increase the flashing frequency of the bicycle light 100 as the bicycle speed increases to further raise the awareness of the bicycle. In an implementation, the bicycle headlight 100 may comprise individual LEDs, such that the brightness of each LED contained in the headlight 100 may be individually adjusted by the controller 155.

[0017] In the present embodiment, for a cyclist riding on well-lit roads, the system may reduce the bicycle light element brightness and/or intensity to minimize the power consumption and maximize battery life. For light element brightness, the ambient light sensor 150 may be used for automatically reducing the light element brightness and/or intensity. The ambient light sensor 150 may be used to provide a percentage brightness value. That percentage could be used to set the brightness of the light element. For example, if the ambient light sensor 150 returns a 20% brightness level, then the light element should be set to 80% of its brightness capacity to account for the reduced ambient lighting. In addition, the adjustment to the pulsing frequency and brightness may be made by operational signals generated by the controller 155, and may also be based on the other various sensors, such as an accelerometer, a gyroscope, a handlebar/steering sensor 180, in addition to the ambient light sensor 150.

[0018] In an implementation, bicycle headlights 100 may allow users to manually change the bicycle light brightness/intensity through a user interface that would override or influence the operational signals generated by the controller 155. One advantage of the disclosed system is that it may automatically find the optimal pitch and yaw of the headlight 100 to produce the most efficient lighting angles of the light, and it may also adjust the light brightness/intensity to

optimize lighting the road ahead and power consumption, while being customizable with user inputs. In an implementation for automatically finding the optimal pitch and yaw of a headlight 100, a gyroscope may be used. The automatic adjustment can be determined by the change in pitch (ΔP) and yaw (ΔY) angle values from the gyroscope. In addition, the yaw position of the headlight 100 can be determined by some factor of the acceleration in the x-direction. For example, $k * a_{cx}$, where k is some constant to translate the acceleration into an angle (Δ) for the headlight 100 to move.

[0019] FIG. 2 illustrates a schematic of a bicycle headlight system 200 comprising a light element 202 made of a plurality of light emitting diodes (LEDs) 217 disposed in an array, which are being digitally driven by an LED drive circuit 215 responsive to operational signals generated by a controller 220. The system may further comprise a plurality of sensors that are electrically connected to the controller 220. For example, the system sensors may be: a gyroscopic sensor 230, an accelerometer 240, an ambient light sensor 250, etc. In an implementation, the gyroscopic sensor 230 and the accelerometer 240 may be used to determine the position of the handlebars, and inputs made to the handlebars by a cyclist. Data generated by the sensors may be received by the controller 220, which then generates operational signals that are transmitted to the electrically connected LED drive circuit 215 and to a plurality of motors that are configured to physically move the headlight 200. The plurality of motors may comprise a pitch motor 205 that adjusts the pitch of the headlight 200, and a yaw motor 210 that adjusts the yaw of the headlight 200. As can be seen in the figure, the motors are shown over arrows that are intended to disclose their direction of adjustment for the headlight 200.

[0020] As described above, the LED drive circuit 215 may drive the plurality of LEDs 217 in a flashing pattern that is both attention getting and battery preserving. The flashing pattern may

vary in frequency and duration. For example, the duration at which the LEDs 217 are on may be varied, as well as the duration at which the LEDs 217 are off. Additionally, flashing patterns may be varied responsive to changing environmental conditions. In the present implementation, each of the LEDs 217 in the LED array may be controlled independently or may be controlled in concert by the controller 220 and the LED drive circuit 215. It will be appreciated that the individual LED lights 217 should be sufficient in providing visibility of the road for a bicycle rider. By way of example, the light element 202 comprising the plurality of LEDs 217 is shown in FIG. 2 as having five LEDs, namely LED#1, LED#2, LED#3, LED#4, and LED#5. Although, it will be appreciated that any number of LEDs may be utilized without departing from the scope of the disclosure. For the five LEDs 217 illustrated in FIG. 2, the LED lighting pattern may include turning on only one of the LEDs (e.g., LED#1) at a time, and then within 300 milliseconds for example, turn on LED#2 while turning off LED#1. That process may be followed-up with turning on LED#3, LED#4, and LED#5 within 300 milliseconds of each other. And the lighting pattern will then continue with LED#1 being on and then turned off and so forth.

[0021] In an implementation, the intensity of the LEDs 217 may be changed, or modulated, along with the flashing pattern in order to provide safety and extend battery life. Additionally, an implementation may comprise a battery power sensor 260 for sensing the condition of the battery. In such an implementation, the battery data generated by the battery power sensor 260 may be used by the controller 220 in generating operational signals and flashing (modulation) patterns. It will be appreciated that during periods of low lighting conditions, the LEDs 217 may be flashing in a particular pattern with a low frequency, but high brightness. Whereas, during

periods of high ambient light conditions, the LEDs 217 may be flashing with a high frequency, but low brightness for power saving.

[0022] FIG. 3 illustrates a computing hardware schematic 300 of an implementation of the headlight system 200 in accordance to the present disclosure. The headlight system 200 may comprise or utilize special purpose or general-purpose computer hardware, such as, for example, one or more processors 305 and system memory 310. Implementations within the scope of the present disclosure may also include physical and other computer-readable media for carrying or storing computer-executable instructions 315 and/or data structures 320. Such computer-readable media can be any available media that can be accessed by a general purpose or special purpose computer system. Computer storage media (devices) includes RAM, ROM, EEPROM, or any other medium which can be used to store desired program code in the form of computer-executable instructions 315 or data structures 320 and which can be accessed by a general purpose or special purpose computer.

[0023] Computer-executable instructions 315 may comprise, for example, instructions and data which, when executed by processor 305, cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions. The computer-executable instructions 315 may be, for example, binaries, intermediate format instructions such as assembly language, or even source code. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the described features or acts described above. Rather, the described features and acts are disclosed as example forms of implementing the claims.

[0024] Further, where appropriate, functions described herein can be performed in one or more of: hardware, software, firmware, digital components, or analog components. For example, one or more application specific integrated circuits (ASICs), such as an LED drive circuit 325, can be programmed to carry out one or more of the systems and procedures described herein, such as driving the LEDs. Certain terms are used throughout the following description and claims to refer to particular system components. As one skilled in the art will appreciate, components may be referred to by different names. This document does not intend to distinguish between components that differ in name, but not function. Alternatively, the systems and procedures described herein can be implemented in hardware, or a combination of hardware, software, and/or firmware.

[0025] FIG. 4 illustrates a method for controlling a bicycle headlight for providing improved illumination in dynamic environments. As can be seen in the figure, a system and method 400 for controlling a bicycle headlight having a light element is illustrated. At 410, the system and method may receive handlebar position data from an accelerometer and gyroscopic sensor that are configured to sense handlebar position.

[0026] It will be appreciated that the accelerometer produces handlebar position data by measuring the amount of static acceleration due to gravity, such that the angle that the handlebar is tilted at with respect to the earth may be determined and calculated. Further, by sensing the amount of dynamic acceleration, the accelerometer can analyze the way the handlebar is moving. It will be appreciated that there are various accelerometers that may be implemented in the system and method of the present disclosure, and any type of accelerometer may be utilized without departing from the scope of the disclosure. For example, some accelerometers use the piezoelectric effect. In such an implementation, the accelerometer may contain microscopic

crystal structures that may be stressed by accelerative forces, thereby causing a voltage to be generated. Another example of an accelerometer senses changes in capacitance between two microstructures next to each other. When an accelerative force moves one of the microstructures, then the capacitance will change, and that change can be sensed. Circuits may then be added to convert capacitance to voltage. It will be appreciated that there are additional types of accelerometers that may be implemented without departing from the scope of the disclosure, including those that use the piezo resistive effect, hot air bubbles, and light.

[0027] Additionally, it will be appreciated that the gyroscopic sensor produces handlebar position data by sensing the rotational motion and changes in handlebar orientation. The gyroscopic sensor may sense the angular velocity produced by the sensor's own movement. The angle is detected, for example, via integration operations by a controller. The gyroscopic sensor may also sense vibration produced by the change in the handlebar's orientation and may transmit that data as electrical signals to the controller. In either case, the handlebar position data reflects the angle or orientation that the handlebar has moved, which data may be fed to the controller and processed into operational signals.

[0028] At 420, the system and method may generate the operational signals that are responsive to the received handlebar position data via the controller that is in electronic communication with the accelerometer, the gyroscopic sensor, a drive circuit configured to drive a light element, a first motor for adjusting pitch of the light element, and a second motor for adjusting yaw of the light element. The operational signals may be generated by the controller using various algorithms, formulas, look-up tables or otherwise to determine the amount of headlight adjustment necessary for a given condition or circumstance.

[0029] At 430, the system and method may drive the first and second motors in accordance with the operational signals in order to change the pitch and yaw of the headlight. Accordingly, at 440, the system and method may further drive the light element to illuminate in accordance with the operational signals. At 450, the system and method may receive ambient light data from an ambient light sensor. The ambient light data may be sent to the controller where it is processed and used to automatically adjust the brightness and intensity of the bicycle light responsive to the sensed ambient light data. For example, if a large amount of ambient light is sensed, then the brightness and intensity of the bicycle light may be reduced or even turned off, depending upon the amount of the ambient light present. Further, if a small amount of ambient light is sensed, then the brightness and intensity of the bicycle light may be increased depending upon the amount of the ambient light present.

[0030] At 460, the system and method may drive a light emitting diode (LED) as the light element or a plurality of LEDs disposed in an LED array. At 470, the controller of the system and method may generate a flash pattern comprising a flash rate and flash duration.

Additionally, at 480, the system and method may generate a light intensity control for the operational signals for varying the intensity of the light element. The method may include the generation of operational signals for controlling each of the plurality of LEDs independently.

[0031] At 485, the system may further comprise sensing a power level for a battery, and may generate adjustments responsive to the sensed battery power level at 490.

[0032] The foregoing description has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed. Many modifications and variations are possible in light of the above teaching.

Further, it should be noted that any or all of the aforementioned alternate implementations may be used in any combination desired to form additional hybrid implementations of the disclosure.

[0033] Further, although specific implementations of the disclosure have been described and illustrated, the disclosure is not to be limited to the specific forms or arrangements of parts so described and illustrated. The scope of the disclosure is to be defined by the claims appended hereto, any future claims submitted here and in different applications, and their equivalents.

CLAIMS

1. A bicycle headlight comprising:
 - a light element;
 - a drive circuit configured to drive the light element;
 - a first motor for adjusting pitch of the light element;
 - a second motor for adjusting yaw of the light element;
 - an accelerometer and gyroscope for sensing handlebar position; and
 - a controller to generate operational signals that are responsive to sensed data comprising:
 - first and second motor drive signals;
 - a light element drive signal.
2. The bicycle headlight of claim 1, further comprising an ambient light sensor, wherein the ambient light sensor sends ambient light data to the controller where it is processed and used by said controller to automatically adjust the brightness and intensity of the light element responsive to said ambient light data.
3. The bicycle headlight of claim 1, wherein the light element comprises a light emitting diode (LED).
4. The bicycle headlight of claim 1, wherein the light element comprises a plurality of LEDs disposed in an LED array.

5. The bicycle headlight of claim 1, wherein the light element drive signal comprises a flash rate and flash duration.

6. The bicycle headlight of claim 1, wherein the light element drive signal comprises light intensity control.

7. The bicycle headlight of claim 4, wherein the light element drive signal comprises instructions to control each of the plurality of LEDs independently.

8. The bicycle headlight of claim 1, further comprising a battery and a corresponding sensor for sensing a battery power level.

9. The bicycle headlight of claim 8, wherein the operational signals comprise adjustments generated by the controller responsive to sensed battery power level.

10. The bicycle headlight of claim 1, further comprising manual controls whereby a user may override and adjust the operational signals generated by the controller.

11. A method for controlling a bicycle headlight having a light element comprising:
receiving handlebar position data from an accelerometer and gyroscopic sensor that are configured to sense handlebar position;
generating operational signals that are responsive to the received handlebar position data with a controller that is in electronic communication with the accelerometer, the

gyroscopic sensor, a drive circuit configured to drive a light element, a first motor for adjusting pitch of the light element, and a second motor for adjusting yaw of the light element;

driving the first and second motors in accordance with the operational signals; and
driving the light element in accordance with the operations signals.

12. The method of claim 11, further comprising receiving ambient light data from an ambient light sensor, wherein the ambient light data is sent from the ambient light sensor to the controller where it is processed and used by said controller to automatically adjust the brightness and intensity of the light element responsive to said ambient light data.

13. The method of claim 11, further comprising driving a light emitting diode (LED) as the light element.

14. The method of claim 11, further comprising driving a plurality of LEDs disposed in an LED array as the light element.

15. The method of claim 11, further comprising generating a flash rate and flash duration for the operational signals.

16. The method of claim 11, further comprising generating a light intensity control for the operational signals.

17. The method of claim 14, further generating operational signals for controlling each of the plurality of LEDs independently.

18. The method of claim 11, further comprising sensing a battery power level for a battery.

19. The method of claim 18, further comprising generating adjustments responsive to sensed battery power level.

20. The method of claim 11, further comprising receiving user inputs from manual controls and overriding the operational signals generated by the controller.

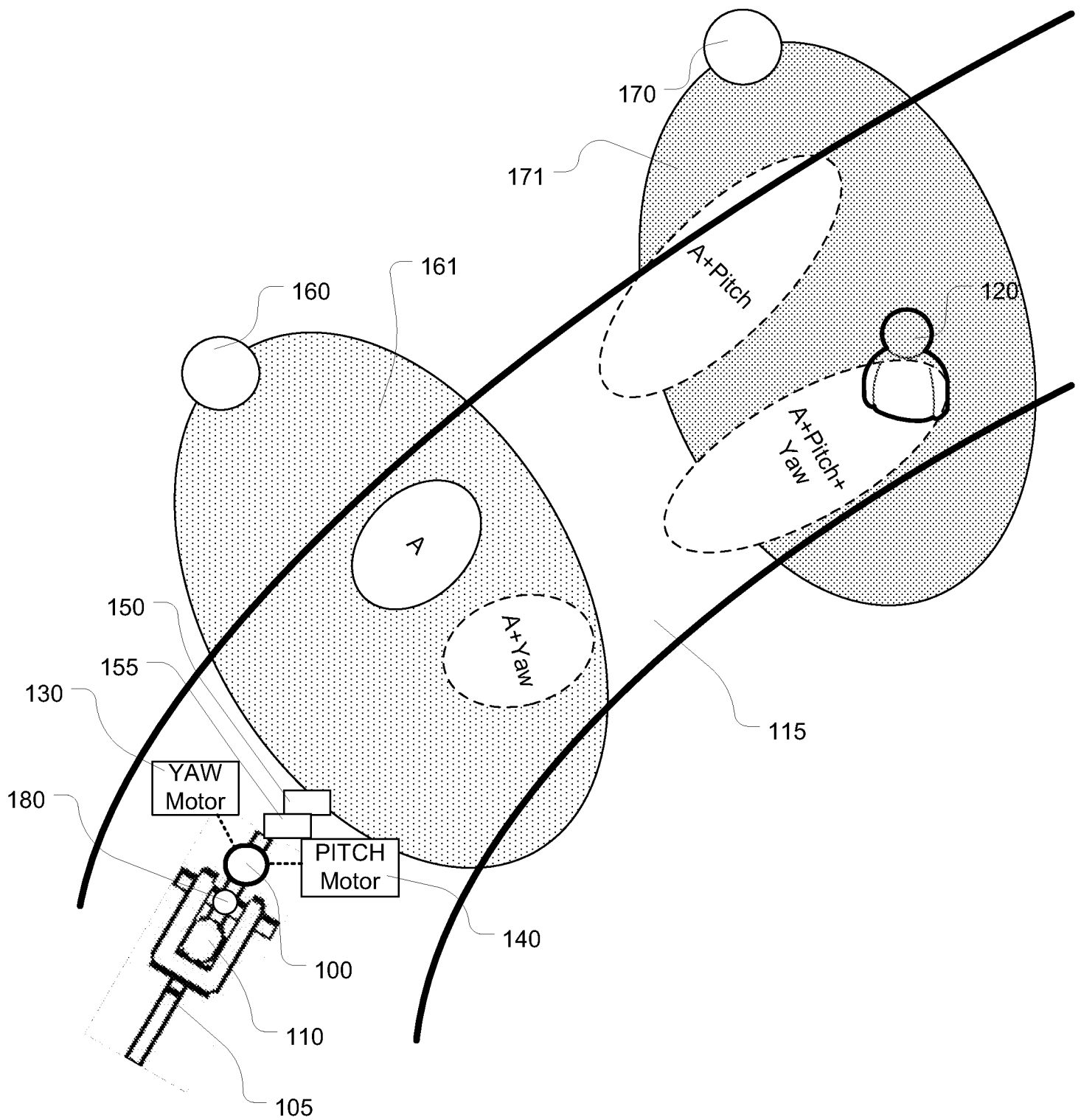


FIG. 1

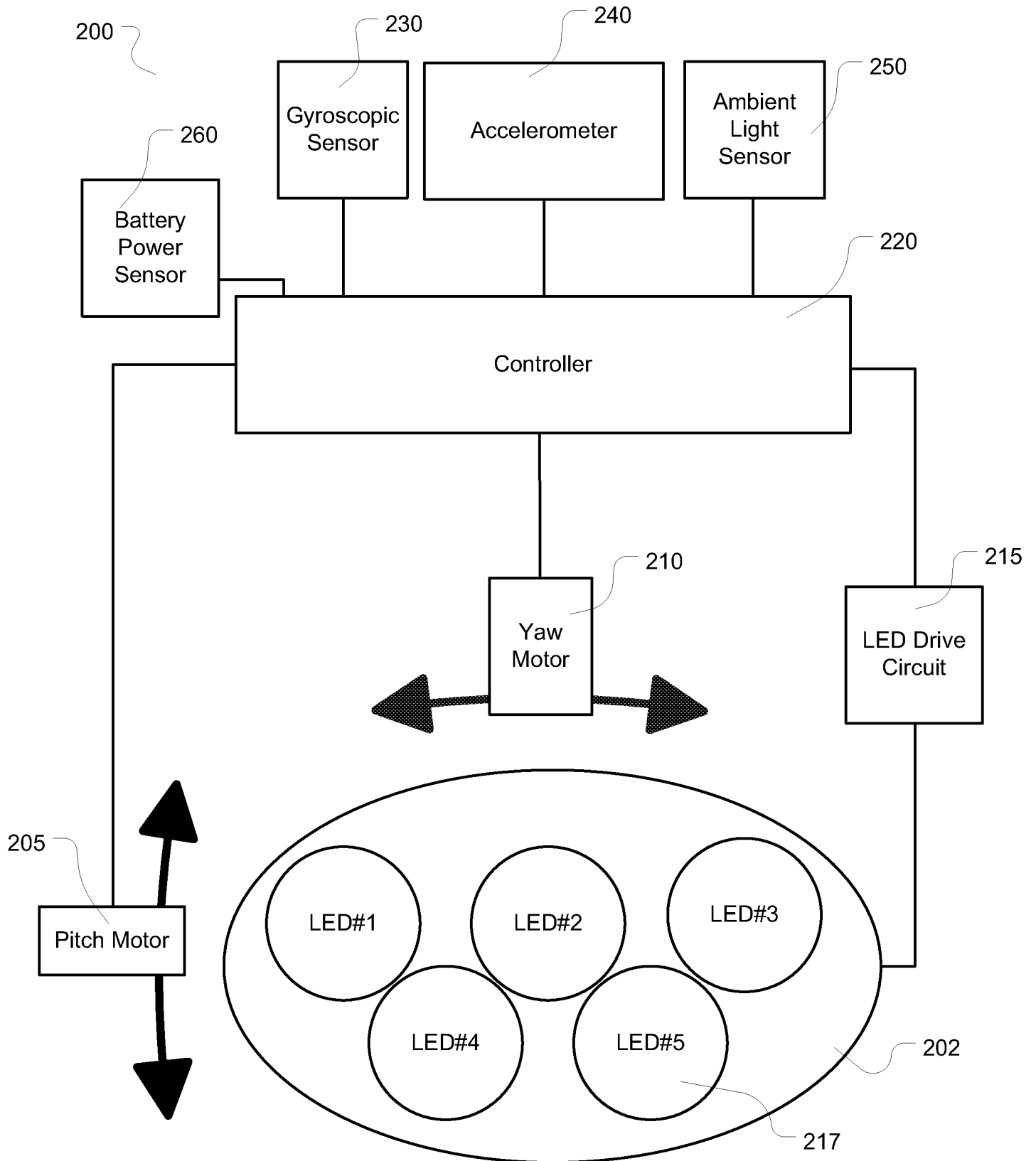


FIG. 2

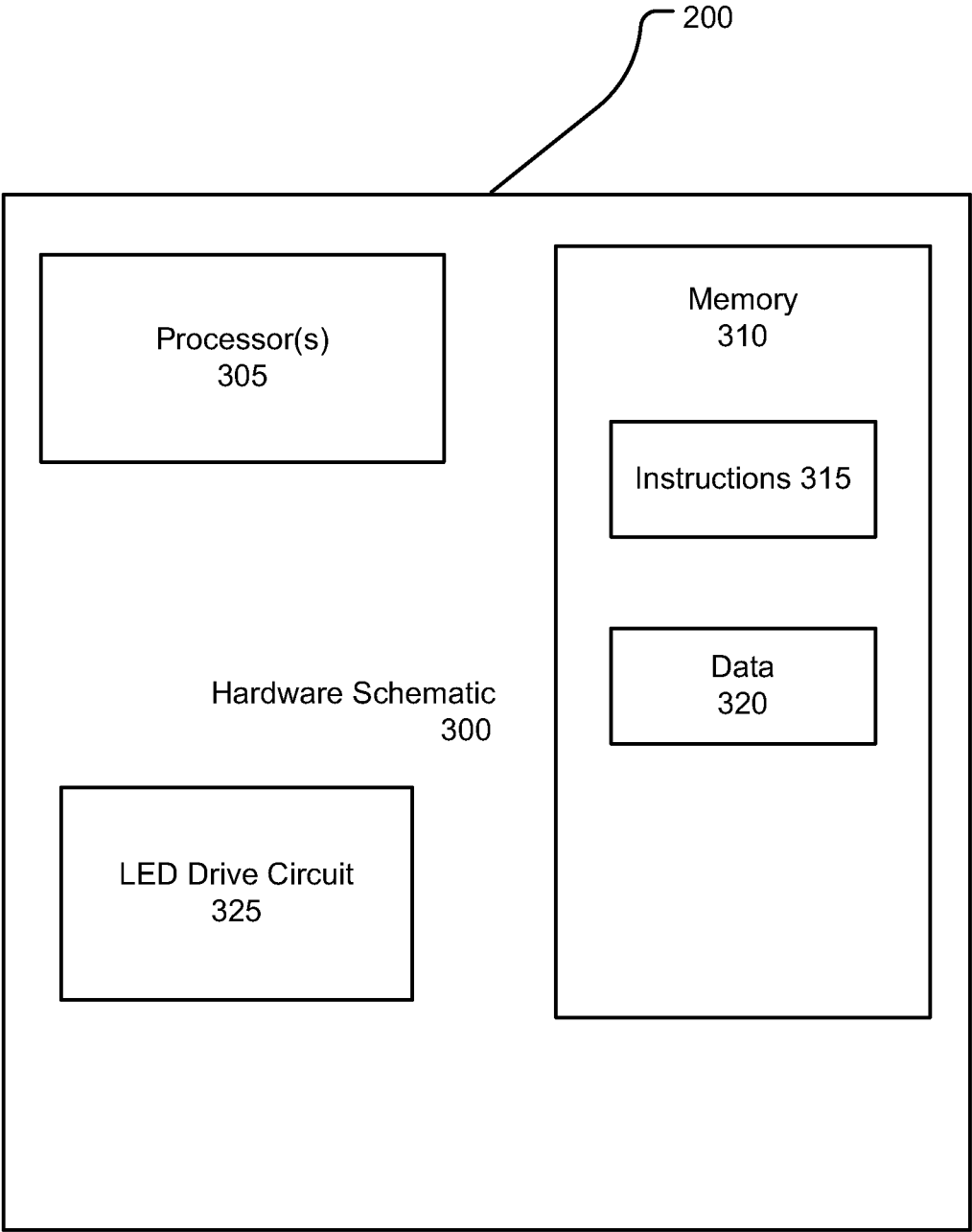


FIG. 3

400

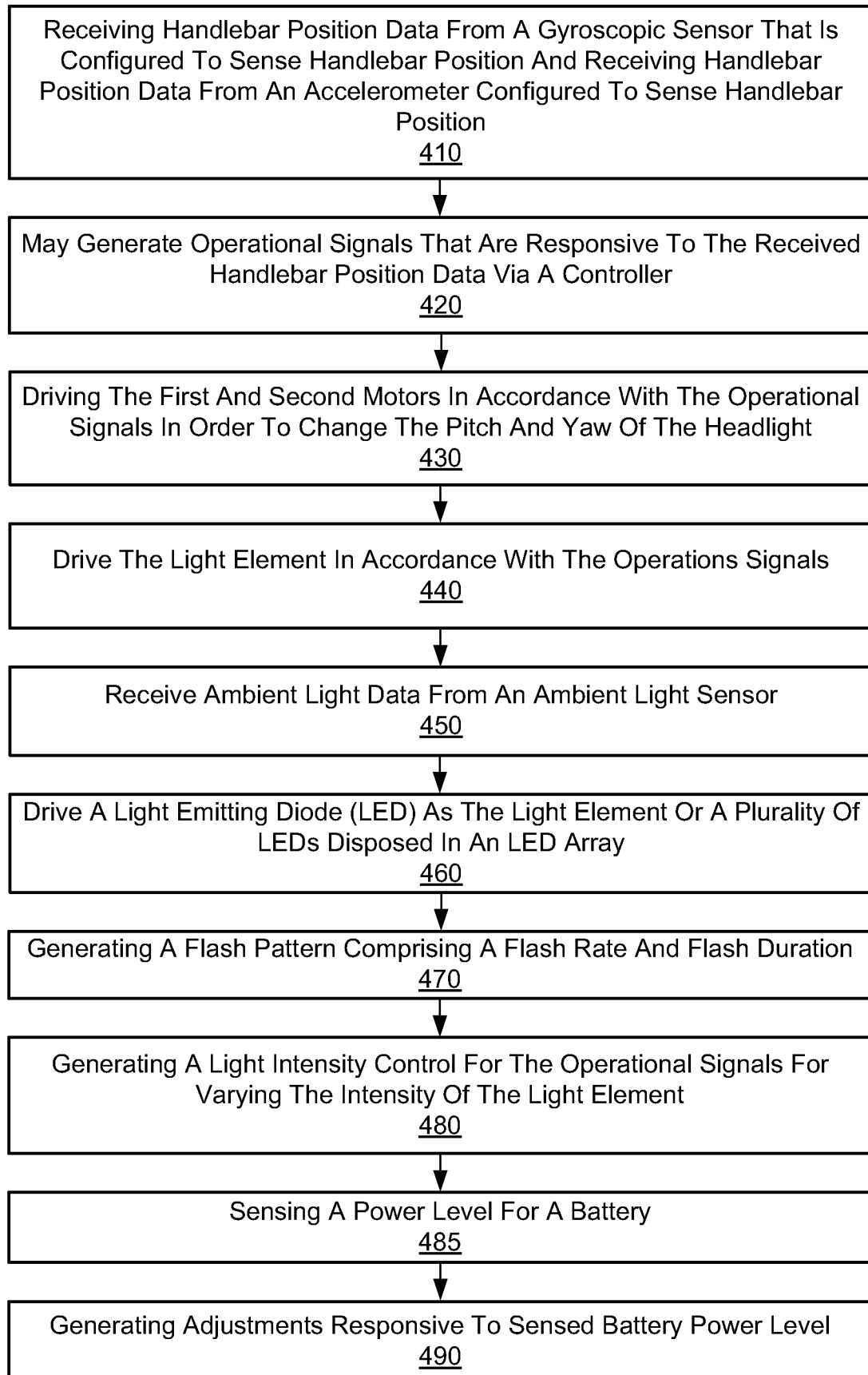


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B62J 6/02 (2015.01)

CPC - B62J 6/02 (2015.04)

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)

IPC(8) - B60Q 1/00, 1/02, 1/04, 1/06, 1/08, 1/12, 1/26; B62D 37/00, 37/06; B62J 6/00, 6/02, 6/08, 6/10, 6/12 (2015.01)
USPC - 362/464, 465, 466, 473, 475; 446/440, 468; 701/36, 124; 702/151

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

CPC - B60Q 1/00, 1/02, 1/04, 1/06, 1/08, 1/26; B62D 37/00, 37/06; B62J 6/00, 6/02, 6/08, 6/10, 6/12 (2015.04) (keyword delimited)

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

Orbit, Google Patents, Google Scholar, Google.

Search terms used: headlight, bicycle, bike, motor, actuator, pitch, yaw, accelerometer, gyroscope, control, handlebar, position, driver.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,870,545 A (HATANAKA et al) 26 September 1989 (26.09.1989) entire document	1-20
Y	US 2003/0114974 A1 (SMITH et al) 19 June 2003 (19.06.2003) entire document	1-20
Y	US 2015/0081168 A1 (MCWITHEY et al.) 19 March 2015 (19.03.2015) entire document	1-20
Y	US 2005/0180150 A1 (OKADA et al.) 18 August 2005 (18.08.2005) entire document	2,12
Y	US 4,290,047 A (LATTA, JR.) 15 September 1981 (15.09.1987) entire document	5,15
Y	US 2005/0099787 A1 (HAYES) 12 May 2005 (12.05.2005) entire document	8-10, 18-20
A	US 2015/0062936 A1 (VISION WORKS IP CORPORATION) 05 March 2015 (05.03.2015) entire document	1-20
A	US 7,495,549 B2 (ACRES) 24 February 2009 (24.02.2009) entire document	1-20
A	US 2013/0033370 A1 (LANGLOIS) 07 February 2013 (07.02.2013) entire document	1-20
A	US 5,896,085 A (MORI et al.) 20 April 1999 (20.04.1999) entire document	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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