(12) UK Patent Application (19) GB (11) 2533078 (13) A

(43) Date of A Publication 15.06.2016

(21) Application No: 1415609.5

(22) Date of Filing: 03.09.2014

(71) Applicant(s):
Timur Artemev
Aldworth House, Tennyson's Lane, HASLEMERE, Surrey, GU27 3BJ, United Kingdom

(72) Inventor(s):
Timur Artemev

(74) Agent and/or Address for Service:
Elkington and Fife LLP
Prospect House, 8 Pembroke Road, SEVENOAKS, Kent, TN13 1XR, United Kingdom

(51) INT CL:
B62K 1/00 (2006.01)

(56) Documents Cited:
WO 2014/064887 A1
CN 203473073 U
JP 2011068165 A
US 20120243822 A1
US 20120166049 A1
AU2004200265
WO 2012/017335 A1
JP 2011164040 A
KR 100789906 B
US 20120175176 A1

(58) Field of Search:
INT CL **B62J, B62K**
Other: **EPODOC & WPI**

(54) Title of the Invention: **Entity presence detection system for a self-balancing powered unicycle device**
Abstract Title: **ENTITY PRESENCE DETECTION SYSTEM FOR A SELF-BALANCING POWERED UNICYCLE DEVICE**

(57) An entity presence detection system 200 for a self-balancing powered unicycle is adapted to detect the presence of an entity on, at or near a part of the powered unicycle and provide an indication of detected entity presence. Operation of the powered unicycle may thus be controlled based on an indication of detected entity presence from the entity presence detection system. The system may include proximity sensors 200, 210 or load sensors in order to detect a user. The proximity sensor can utilize infra-red reflection, ultrasonic sensing, microwave sensing, pressure sensing, temperature sensing, or light detection. The unicycle comprises a single wheel 120, a drive arrangement 135, a balance control system, at least one platform, the entity presence detection system 200, and a control system. It can further comprise casing 110 which covers a portion of the outer rim 130 of the wheel, and a handle 180 for lifting the unicycle.

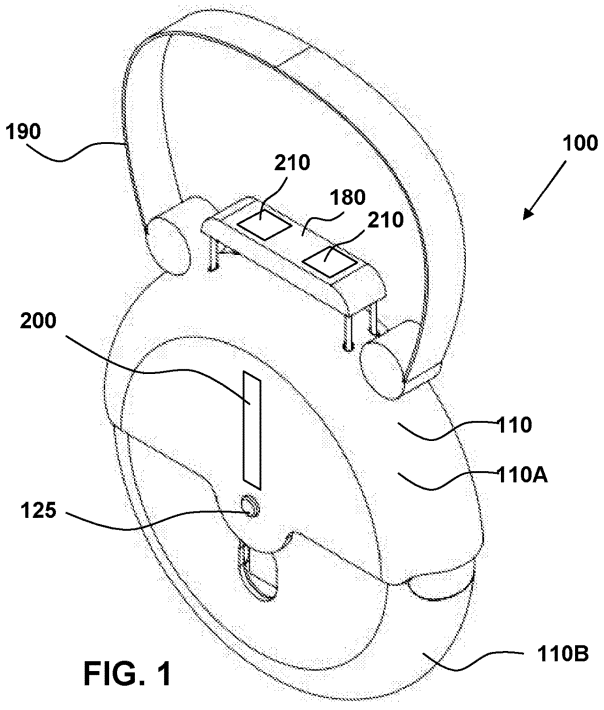

FIG. 1

GB 2533078 A

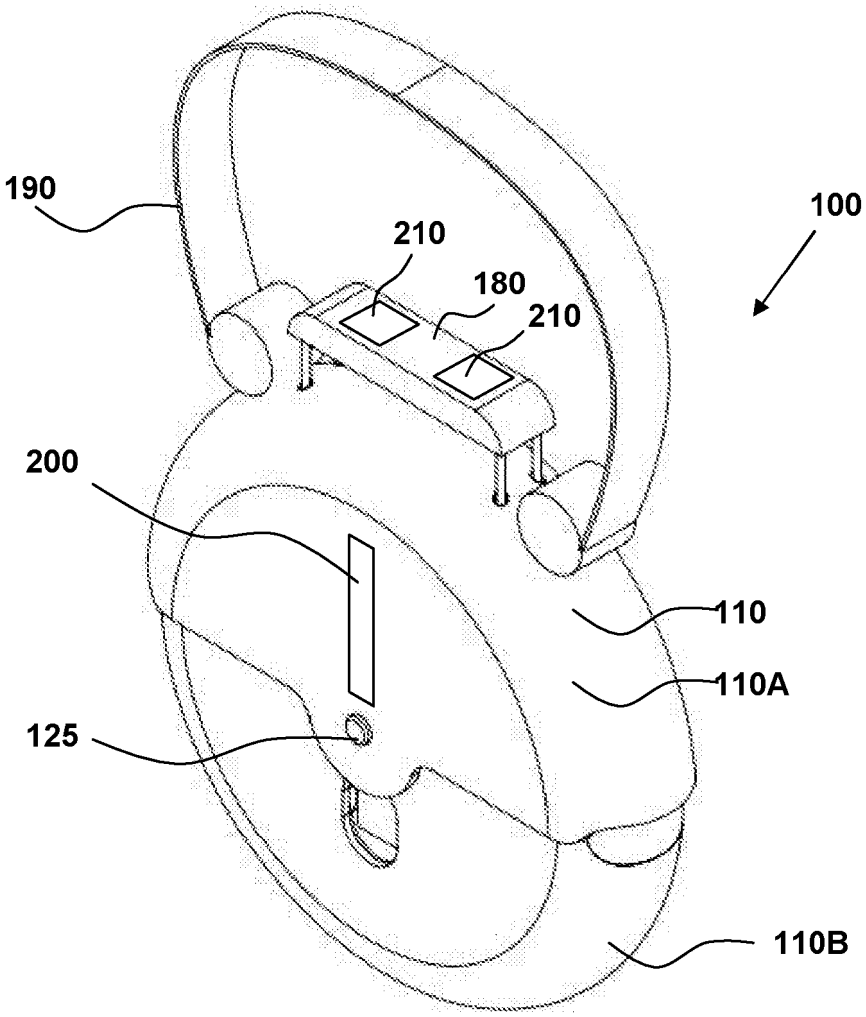

FIG. 1

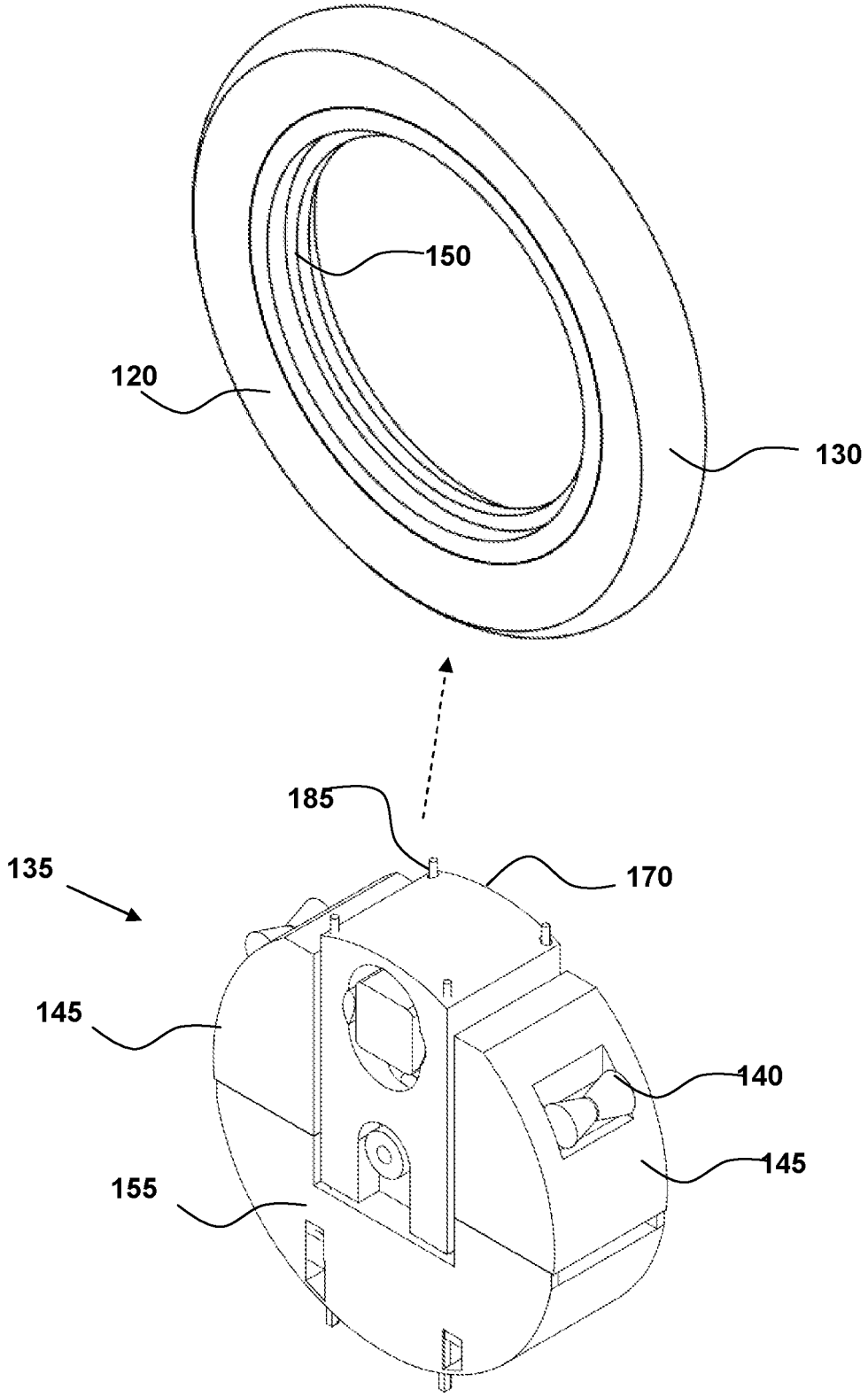

FIG. 2

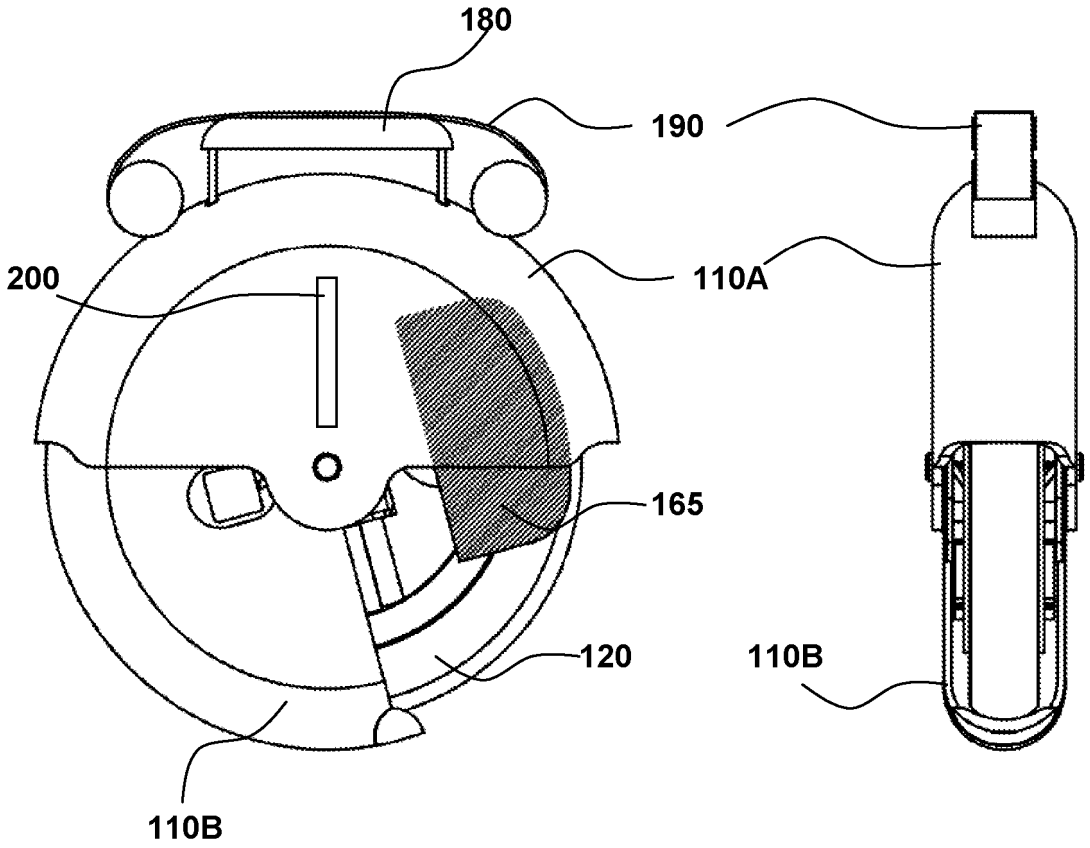

FIG. 3

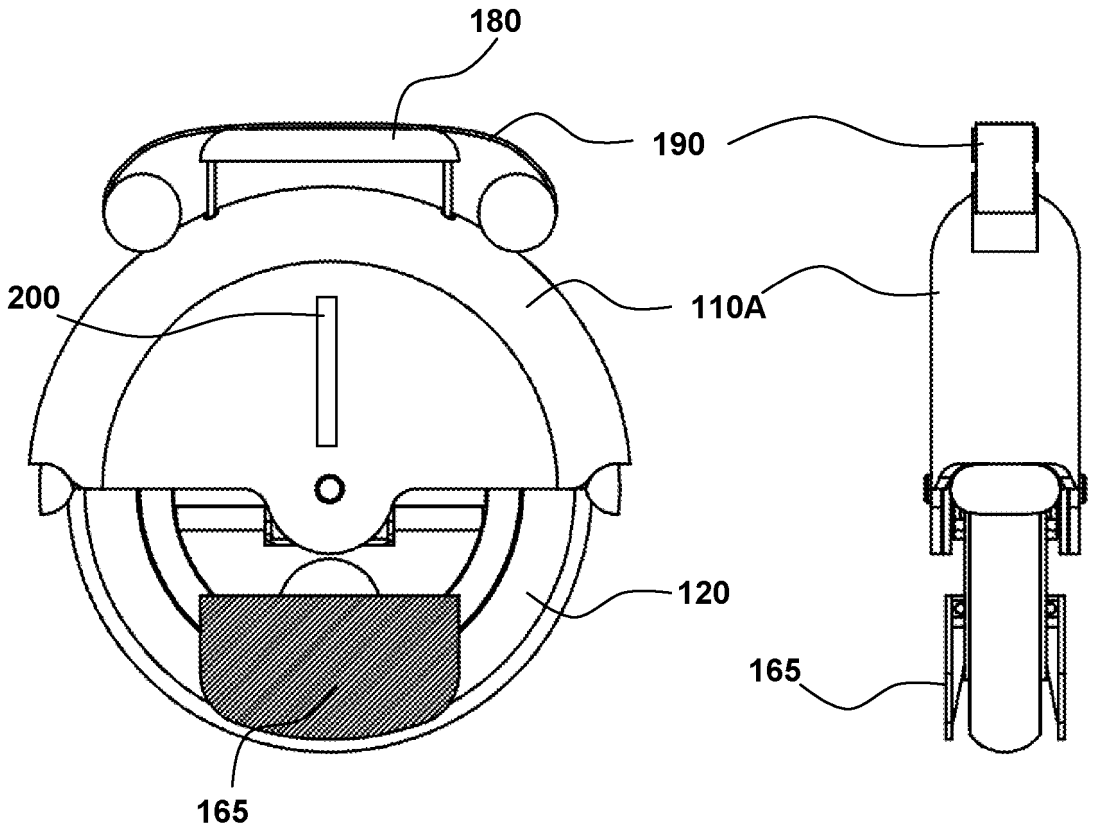

FIG. 4

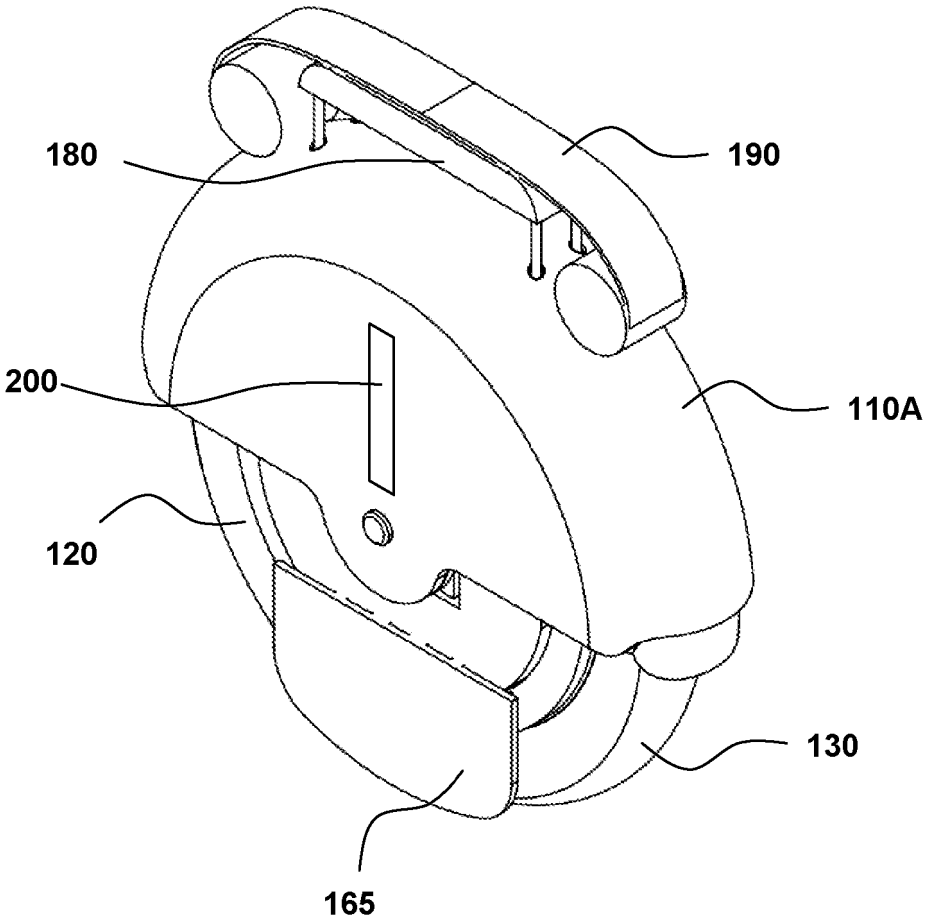

FIG. 5

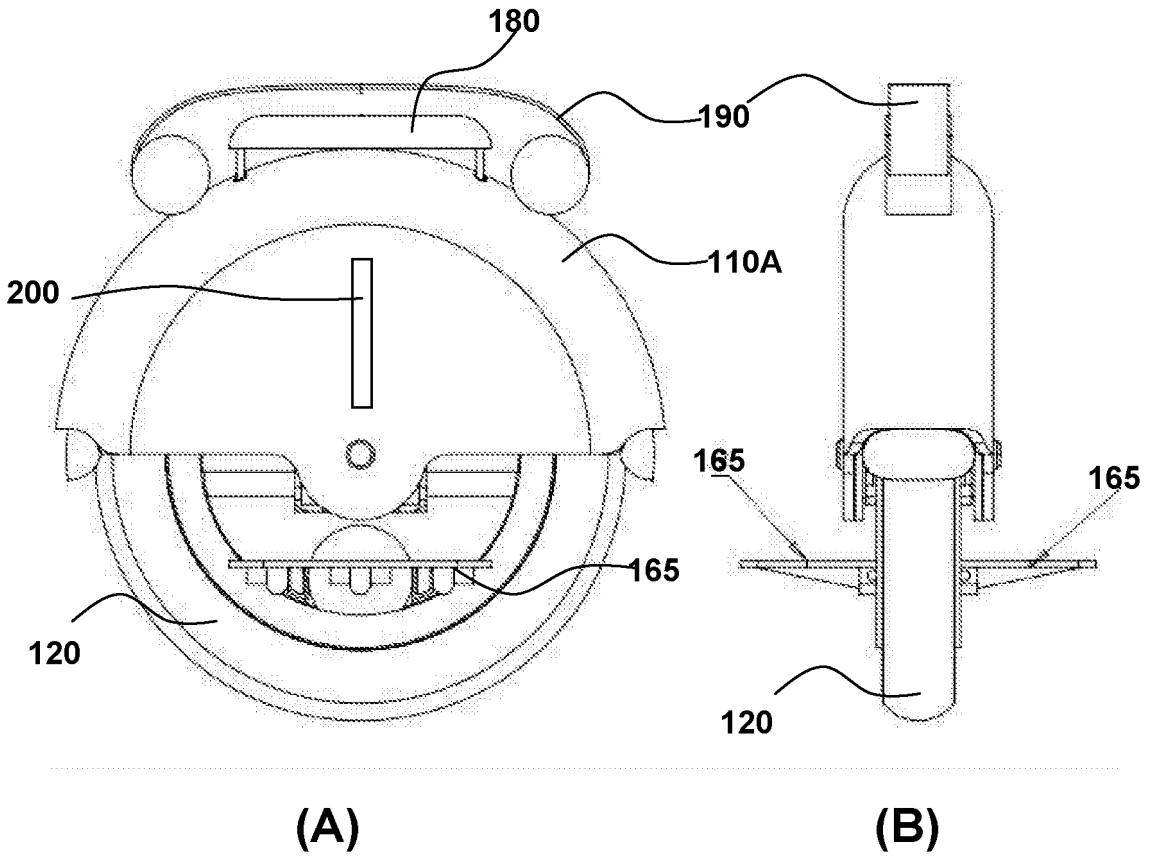

FIG. 6

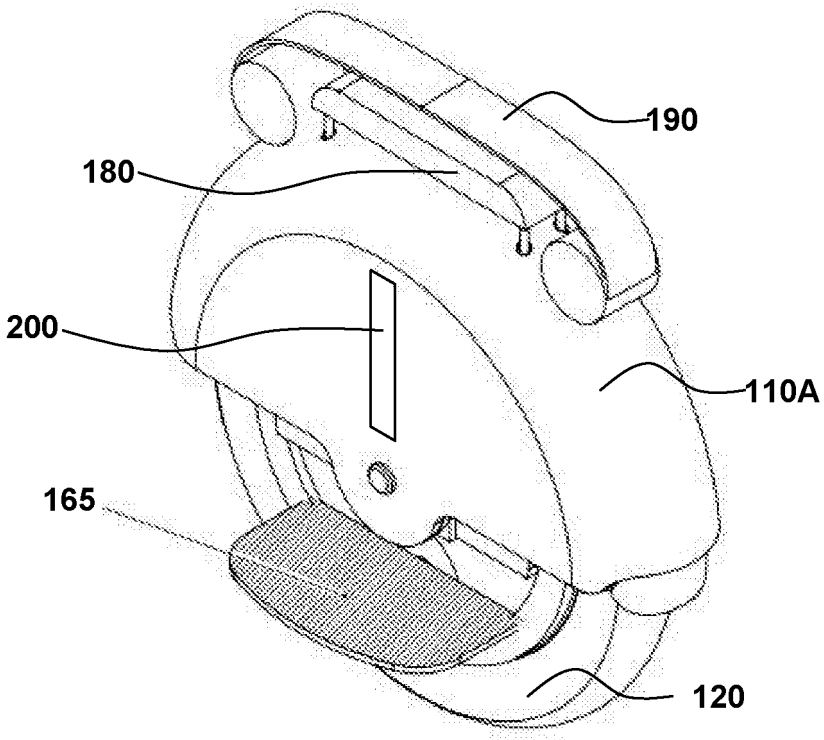

FIG. 7

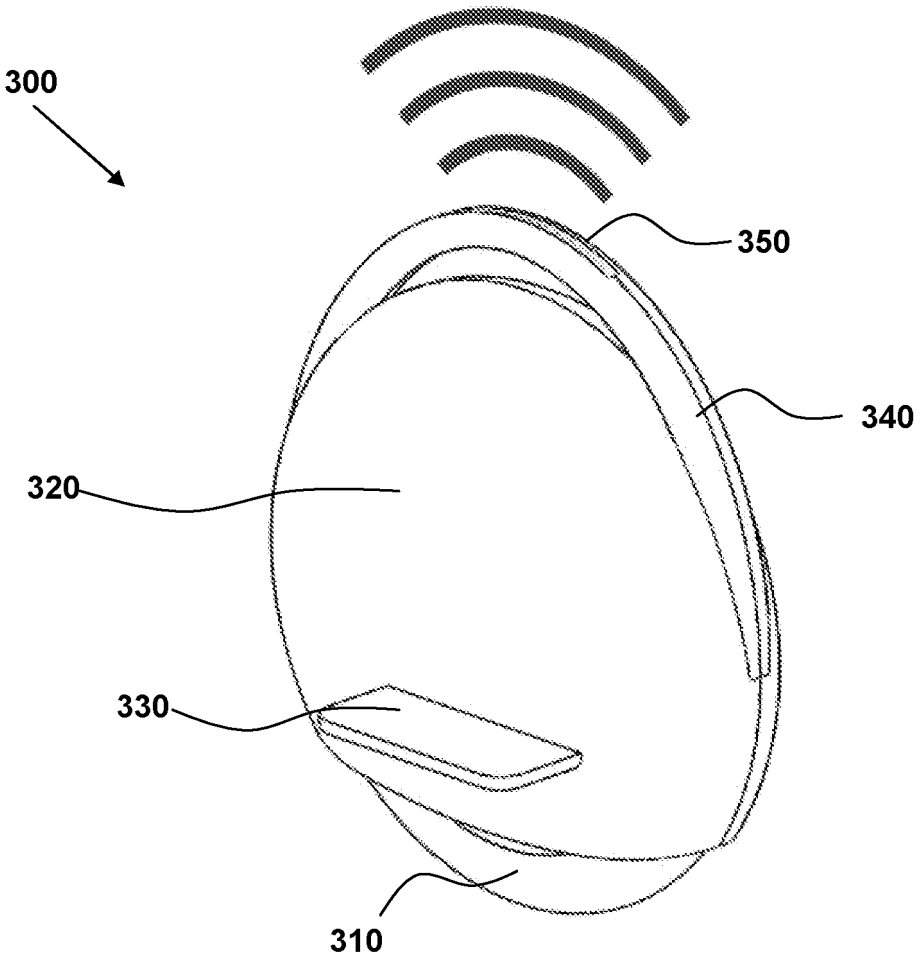

FIG. 8

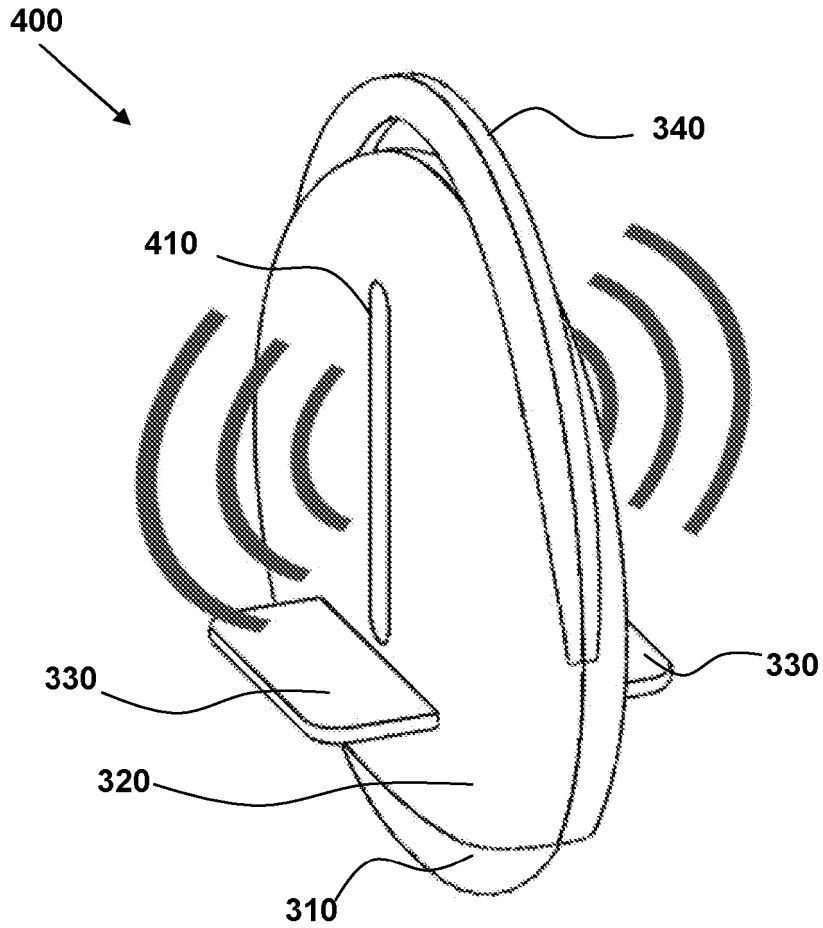

FIG. 9

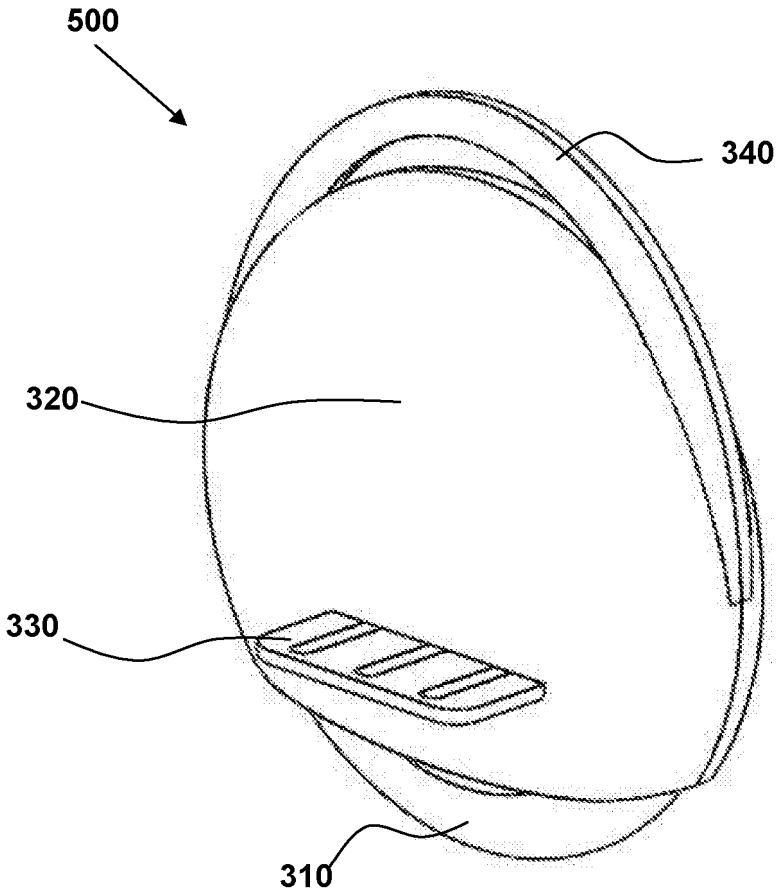

FIG. 10

ENTITY PRESENCE DETECTION SYSTEM FOR A SELF-BALANCING POWERED UNICYCLE DEVICE

Field of Invention

The present invention relates to powered single-wheeled devices and more particularly to powered unicycles with self-balancing functionality.

Background to the Invention

Powered self-balancing vehicles for use while standing are known. Such vehicles include two-wheeled vehicles and single-wheeled vehicles (i.e. unicycles).

In a powered self-balancing unicycle, an electronic or mechanical system that controls the wheel in the appropriate direction is typically used to achieve fore-and-aft balance. This type of automatic fore-and-aft balance technology is well known and described, for example, in United States Patent number 6,302,230. A sensor and electronic equipment are typically provided. Information detected by the sensor and the electronics is relayed to a motor. The motor drives the wheel in the appropriate direction and at sufficient speed to maintain fore-and-aft balance.

Known embodiments of a powered self-balancing unicycle do not include a handle bar supported by a shaft. For example, United States Patent Application Serial Number 12/281,101 presents a single wheel, coupled to a frame to which two platforms (one on each side of the wheel) are attached.

Summary of the invention

According to a first aspect of the invention, there is provided a self-balancing powered unicycle comprising: a single wheel; a drive arrangement adapted to drive the wheel; a balance control system adapted to maintain fore-aft balance of the unicycle device; at least one foot platform for supporting a user of the unicycle device; an entity presence detection system adapted to detect the presence of an

entity on, at or near a part of the powered unicycle and provide an indication of detected entity presence; and a control system adapted to control operation of the powered unicycle based on the indication of detected entity presence from the entity presence detection system.

There is proposed a self-balancing powered unicycle comprising an entity presence detection system that is arranged to detect the presence of an entity on, at or near the powered unicycle. Based on a detected presence or non-presence of an entity (such as a user for example), the operation of the unicycle may be controlled. In other words, the unicycle may be adapted to alter its operation depending on whether or not an entity is present on the unicycle. For example, operation of a drive arrangement of the unicycle may be prevented when no user is present on the unicycle. By way of further example, operation of a drive arrangement may be altered to provide an improved or desired response based on characteristics or properties a detected presence.

The entity presence detection system may, for example, provide an indication that a user is present on the unicycle and wishes to use the unicycle device. Embodiments may therefore allow for rapid deployment by being adapted to automatically activate a drive arrangement and/or the balance control system of the unicycle when a user stands on the unicycle. Similarly, embodiments may enable rapid disablement by being adapted to automatically de-activate a drive arrangement and/or the balance control system of the unicycle when a user dismounts from the unicycle. Such automatic activation/de-activation may provide power savings, and may also improve device safety by altering operation (e.g. stopping the motor from turning the wheel) when a user alights the unicycle (intentionally or accidentally).

An entity presence detection system of a proposed embodiment may provide an indication or signal which is used by a control system to alter operation of the unicycle upon occurrence of one or more predetermined conditions indicating an entity is present or not-present on the unicycle. Such embodiments may therefore enable quick and easy deployment from an off configuration (wherein the rotation of the wheel is disabled, for example) to an on configuration (wherein rotation of the wheel is enabled, for example). This deployment may require little or no input from

the user, but instead may be automatically achieved when the user is in close proximity with, or contacts) one or more predetermined parts of the unicycle.

Embodiments may enable the powered unicycle to automatically disable if the user alights or dismounts from the unicycle (e.g. by intentionally stepping off the foot platform(s) or by falling off). The entity presence detection system may therefore facilitate multiple functions, including the provision of an automatic power saving mode, the provision of quick start-up/deployment, and the provision of an automatic-shutdown safety feature. The entity presence detection system may thus provide not only for improved user interaction, but also for improved safety and to protect the unicycle.

The entity presence detection system may comprise one or more proximity sensors adapted to detect the existence of an entity in close proximity with the proximity sensor. Further, at least one of the one or more proximity sensors may employ at least one of: infrared reflection; ultrasonic sensing; microwave sensing; pressure sensing; temperature sensing; and light detection to detect the existence of an entity in close proximity with the proximity sensor.

An embodiment may further comprise a handle for lifting the unicycle. Such a handle may be used to hold the unicycle above the ground, for example to enable a user to lift, carry, convey or place the unicycle. The handle may also comprise part of the entity presence detection system so that the handle (or a part thereof) may be used to provide an indication of detected user presence and thus control operation of the powered unicycle. For example, the handle may comprise a proximity sensor.

An embodiment may further comprise a casing adapted to cover at least a portion of the outer rim of the wheel, and the casing may comprise a proximity sensor.

According to another embodiment, the entity presence detection system may comprise a load sensing system adapted to determine a loading applied to at least one part of the powered unicycle. Further, the load sensing system may be adapted to determine at least one of: a deflection of the wheel axel; a compressive force applied to the wheel axel; a deflection of the at least one foot platform; a tensile force

applied to the at least one foot platform; and a compressive force applied to the at least one foot platform, so as determine a loading applied to the at least one foot platform of the powered unicycle. In such embodiments, operation of the unicycle may be based on a value of the loading applied to one or more of its parts. For example, for a heavier user exerting a greater load on the unicycle, the drive arrangement may be adapted to provide extra power for rotating the wheel. Conversely, for a small/lightweight user exerting a lower load on the unicycle, the drive arrangement may be adapted provide reduced power so as to ensure the wheel rotates within a desired speed range (and not too quickly for example) and/or to conserve power/energy.

In some embodiment, the entity presence detection system may comprise a processing unit adapted to process signals in accordance with an algorithm to determine if an entity is present on, at or near a part of the powered unicycle. By way of example, such an algorithm may be adapted to determine if the signals from the drive arrangement and/or the balance control system exhibit a predetermined characteristic indicating the presence or non-presence of a user on the powered unicycle.

The signals from the drive arrangement and/or the balance control system may comprise information relating to at least one of: casing orientation; inclination or angle of a part of the unicycle; value of compressive force applied to at least part of a foot platform; accelerometer data; gyroscope data; motor torque; speed of wheel rotation; and a motor drive voltage.

Embodiments may process signals from the unicycle in accordance with one or more algorithm to identify discrepancies between user control input the unicycle's drive arrangement and/or balance control system, for example. In this way, it may be determined if a user is actively controlling the unicycle or the unicycle is not operating as expected (e.g. as may occur in a 'runaway' situation).

According to yet another embodiment, the entity presence detection system may comprise a vibration sensor adapted to detect a frequency of vibration of at least one part of the powered unicycle. The entity presence detection system may be adapted

to determine the presence or non-presence of a user based on if a detected frequency of vibration of at least one part of the powered unicycle is within a predetermined range.

According to another aspect of the invention, there is provided an entity presence detection system for a self-balancing powered unicycle, wherein the entity presence detection system is adapted to detect the presence of an entity on, at or near a part of the powered unicycle and provide an indication of detected entity presence.

Embodiments may comprise one or more proximity sensors adapted to detect the existence of an entity in close proximity with the proximity sensor.

Embodiments may be further adapted to be integrated into a handle of a self-balancing powered unicycle.

An embodiment may comprise a load sensing system adapted to determine a loading applied to at least one part of a self-balancing powered unicycle.

Some embodiments may comprise a processing unit adapted to process signals in accordance with an algorithm to determine if an entity is present on, at, or near a part of a self-balancing powered unicycle.

In an embodiment, the entity presence detection system may comprise a vibration sensor adapted to detect a frequency and/or amplitude of vibration of at least one part of a self-balancing powered unicycle.

For the avoidance of doubt, reference to a single wheel should be taken to mean the generally circular unit that is positioned between the legs of a user and adapted to rotate about an axis to propel the unicycle in a direction during use. The single wheel may therefore be formed from one or more tyres and/or hubs that are coupled together (via a differential, for example). For example, an embodiment may comprise a single hubless wheel having a single hubless rim with a plurality of separate tyres fitted thereon. Alternatively, an embodiment may comprise a single hubless wheel formed from a plurality of hubless rims (each having a respective tyre fitted thereon),

wherein the plurality of hubless rims are coupled together via a differential bearing arrangement.

Embodiments may provide a self-balancing powered unicycle that can alter its operation depending on the presence of an entity on, at or near a part of the unicycle. For example, the drive arrangement may be automatically enabled or disabled to facilitate rapid and simple operation of the unicycle.

Brief description of the drawings

An example of the invention will now be described with reference to the accompanying diagrams, in which:

FIG. 1 is an isometric view of an embodiment of a powered unicycle device in a closed configuration;

FIG. 2 is an exploded diagram of components internal to the casing of FIG. 1,

FIGS. 3A & 3B are side and front elevations, respectively, of the embodiment of FIG. 1, wherein the casing is moving between a closed and open configuration;

FIGS. 4A & 4B are side and front elevations, respectively, of the embodiment of FIG. 1, wherein the casing is in an open configuration and the foot platforms are in a stowed configuration;

FIG. 5 is an isometric view of the embodiment of FIG. 1, wherein the casing is in an open configuration and the foot platforms are in a stowed configuration;

FIGS. 6A & 6B are side and front elevations, respectively, of the embodiment of FIG. 1, wherein the casing is in an open configuration and the foot platforms are in an active configuration;

FIG. 7 is an isometric view of the embodiment of FIG. 1, wherein the casing is in an open configuration and the foot platforms are in an active configuration;

FIG. 8 is simplified isometric view of another embodiment of a self-balancing powered unicycle device;

FIG. 9 is simplified isometric view of a modified version of the embodiment of FIG. 8; and

FIG. 10 is simplified isometric view of a modified version of the embodiment of FIG. 8;

Detailed description

FIGS. 1-5 show one embodiment of a powered unicycle device 100. FIG. 1 shows the powered unicycle device 100 with a casing 110 in a closed configuration so that it encases a single wheel 120. Here, the casing 110 is formed from a first, upper portion 110A that covers the top (uppermost) half of the wheel 120, and a second, lower portion 110B that covers the bottom (lowermost) half of the wheel 120. FIG 2 illustrates an exploded view of components internal to the casing 110, namely a wheel 120 and drive arrangement 135.

Referring back to FIG. 1, the wheel 120 spins about a central axis 125. The first, upper portion 110A of the casing is retained in a fixed position relative to the central axis 125, whereas the second, lower portion 110B of the casing is adapted to rotate about the central axis 125. Rotation of the second lower portion 110B about the central axis 125 moves the casing between closed and open configurations (as illustrated by FIGS. 3-4). In the closed configuration (shown in FIG.1), the casing 110 encloses the wheel 120 so that the outer rim 130 of the wheel 120 is not exposed. In the open configuration (shown in FIG. 5), the outer rim 130 of the wheel 120 is exposed so that it can contact a ground surface.

Referring now to FIG. 2, rotation of the single wheel 120 is driven by a drive arrangement 135 according to an embodiment. The drive arrangement 135 includes guide wheels 140 attached to an outwardly facing side of respective batteries 145. In this embodiment, there are two pairs of angled guide wheels 140, wherein the two guide wheels in each pair share are tapered or conical such that they have a sloped surface which is not perpendicular to the radial plane of the single wheel 120. Put another way, the contact surface of each guide wheel is inclined with respect to the radial plane of the single wheel 120. The guide wheels 140 of each pair are also positioned spaced apart to provide a gap between the two guide wheels of a pair.

A rib 150 is provided around the inner rim of the wheel 120 and fits into the gap between the two guide wheels 140 in each pair. The guide wheels 140 are therefore adapted to contact with the inner rim of wheel 120 where they spin along with wheel 120 and hold wheel 120 in place by way of the rib 150. Of course, it will be

appreciated that other arrangements, including those with only one guide wheel per battery 145, are possible.

The batteries 145 are mounted on a motor 155 which drives a pair of drive wheels 160 positioned at the lowermost point along the inner rim of the wheel 120. The batteries 145 supply power to motor 155 and, this embodiment, there are two batteries in order to create a balanced distribution of volume and weight. However, it is not necessary to employ two batteries 145. Also, alternative energy storage arrangements may be used, such as a flywheel, capacitors, and other known power storage devices, for example.

The drive arrangement 135 is adapted to be fitted inside the wheel. In other words, the drive arrangement is sized and shaped so that it can be positioned in the void define by the inner rim of the wheel 120. Further, the drive arrangement 135 is movable between a locked configuration and an unlocked configuration.

In the locked configuration, when fitted inside the wheel 120, the drive arrangement 135 engages with the rim of the wheel 120 to prevent its removal from the wheel. Here, in the embodiment shown, the guide wheels 140 contact the inner rim of wheel 120 and hold wheel 120 in place by way of the rib 150 when the drive arrangement is in the locked configuration.

In the unlocked configuration, when fitted inside the wheel 120, the drive arrangement 135 disengages with the rim of the wheel 120 to permit its removal from the wheel. Here, in the embodiment shown, the drive arrangement contracts in size when moved from the locked configuration to the unlocked configuration so that the guide wheels 140 no longer contact the inner rim of wheel 120 and no longer hold the wheel 120 in place by way of the rib 150. Such reduced size (e.g. diameter) of the drive arrangement 135 when in the unlocked configuration thus enables the drive arrangement 135 to be removed from the wheel 120.

It will therefore be understood that the drive arrangement 135 of the illustrated embodiment can be quickly and easily connected or removed to/from the wheel 120 for repair or replacement, for example. Arranging the drive arrangement 135 in the

unlocked configuration permits its removal or fitting from/to the wheel 120 (because, for example, its dimensions when in the unlocked configuration permit its fitting inside the wheel). When fitted inside the wheel 120, the drive arrangement can be arranged in the locked configuration so that it engages with the rim of the wheel 120 to prevent its removal (because, for example, its dimensions when in the locked configuration prevent the drive arrangement from being removed from the wheel).

When the drive arrangement 135 is fitted inside the wheel and in the locked configuration, a pair of drive wheels (not visible in Figure 2) is adapted to contact the inner rim of the wheel 120. Here, the pair of drive wheels comprises first and second rollers that are inclined with respect to the radial plane of the wheel. By way of contact with the inner rim of the wheel 120, the drive wheels transmit torque from the motor 155 to the wheel 120. It will be understood that this drive system operates by friction and it may be preferable to avoid slippage between the drive wheels and the inner rim of wheel 120. Positioning the drive wheels at the lowermost point enables the weight of a user to provide a force which presses the drive wheels against the inner rim of the wheel 120, thereby helping to reduce or avoid slippage.

Referring to FIGS. 5-7, two foot platforms 165 are coupled to the second, lower portion 110B of the casing 110, with one on each side of wheel 120. In the open configuration, the foot platforms 165 are movable between a stowed configuration, wherein the foot platforms are substantially parallel with the plane of the wheel (as shown in FIG. 5), and an active configuration, wherein the foot platforms are substantially perpendicular to the plane of the wheel (as shown in FIGS. 6-7) so as to support a user's weight. Thus, in this embodiment, the foot platforms 165 are movable between: (i) a stowed configuration wherein they are flat against the side of the wheel and can be rotated (with the second, lower portion 110B of the casing) about the central axis 125 so as to be positioned inside (and covered by) the first, upper portion 110A of the casing; and (ii) an active configuration, wherein they project outwardly from the side of the wheel to provide a support surface for the feet of a user. Accordingly, the foot platforms 165 are upwardly foldable into a stowed configuration that narrows the profile of the unicycle 100 to aid in storage and carrying. In use, the foot platforms are moved to the active configuration, and the user stands with one foot on each platform 165.

The drive arrangement 135 includes a gyroscope or accelerometer system 170 which senses forward and backward tilt of the device in relation to the ground surface and regulates the motor 155 accordingly to keep the device upright. In this way, the user is provided a way of controlling the acceleration and deceleration of the unicycle by varying the pressure applied to various areas of the foot platforms 165. It also enables the unicycle to self-regulate its balance in the fore-and-aft plane.

When not in use, the foot platforms 165 are moved to the stowed configuration and then rotated (with the second, lower portion 110B of the casing) about the central axis 125 so as to move the casing to the closed configuration. Thus, in the closed configuration, the foot platforms 165 are stored inside the casing (covered by the first, upper portion 110A of the casing).

The embodiment of FIGS. 1-7 also comprises a lifting handle 180 coupled to the drive arrangement 135 via a plurality of rods 185. The lifting handle 180 is positioned at the top of the casing 110, above the wheel 120, and may be used to hold the unicycle 100 above the ground, for example to enable a user to lift, carry, convey or place the unicycle 100.

A retractable carrying strap 190 is also provided and attached to the top of the casing 100. The carrying strap 190 may be used to carry the unicycle 100, for example over the shoulder of user. A hook may be provided on the bottom of the case to create rucksack-like belts from the carrying strap 190.

The embodiment of FIGS. 1-7 also comprises an entity presence detection system 200 adapted to detect the presence of a user. More specifically, in this embodiment, the entity presence detection system 200 comprise a proximity sensor 200 situated on each side of the first, upper portion 110A of the casing above the central axis 125. Each proximity sensor 200 is adapted to detect the existence of a user's leg in close proximity with the proximity sensor 200. In order to do this, the proximity sensors 200 may, for example, employ infrared reflection, ultrasonic sensing, and/or and light detection principles to detect if/when a user's leg is positioned in close proximity with the proximity sensor (e.g. contacting the first, upper portion 110A of the casing).

The proximity sensors 200 provide a signal indicating whether or not a user's presence it detected. This signal is provided to a control system (not shown) which is to control operation of the powered unicycle, by controlling the drive arrangement 135 for example. Based on an indication of detected user presence provided by the signal(s) from the proximity sensors 200, the control system controls operation of the powered unicycle.

Here, the entity presence detection system 200 is also adapted to trigger an activating system which moves the casing between the closed and open configurations. More specifically, the entity presence detection system 200 further comprises proximity sensors 210 incorporated into the handle 180 which are adapted to detect when a user's hand contacts the upper surface of the handle (e.g. when a user grips the handle 180). When one of the proximity sensors 210 incorporated into the handle 180 detects a user's hand contacting the upper surface of the handle 180, it provides an activation signal which triggers the activating system which, in turn, causes the second, lower portion 110B of the casing to rotate about the central axis to move from the closed configuration to the open configuration. This process of rotating the second, lower portion 110B of the casing from the closed configuration to the open configuration is depicted by FIGS. 3-4.

It will therefore be understood that, in this embodiment, the proximity sensors 210 in the lifting handle 180 may be used to initiate the activating system and move the casing from the closed configuration to the open configuration. Thus, when a user holds the unicycle 100 by the handle, the proximity sensors 210 triggers the activating system. In response to this trigger, the activating system moves the casing to the open configuration (depicted in FIGS. 4 & 5) so that the lowermost portion of the wheel is exposed and can be brought into contact with a ground surface. In other words, when lifted by the lifting handle 180, the unicycle may be arranged in an open configuration ready for deployment (e.g. placement on a ground surface).

Further, when placed on the ground and the balance control system is activated, release of the handle causes the foot platforms to move from the stowed

configuration (shown in FIGS. 4 & 5) to the active configuration (shown in FIGS. 6 & 7).

When the user no longer desires to use the unicycle, the user grips the lifting handle to lift the unicycle from the ground. This results in the proximity sensors 210 triggering the activating system once again which then causes the foot platforms to move from the active configuration (shown in FIGS. 6 & 7) to the stowed configuration (shown in FIGS. 4 & 5), and then subsequently causes the activating system to move the casing from the open configuration (depicted in FIGS. 4 & 5) to the closed configuration (depicted in FIG. 1).

Turning now to FIG. 8, there is depicted a self-balancing powered unicycle 300 according to an embodiment of the invention.

The self-balancing powered unicycle 300 comprises: a single wheel 310; a drive arrangement (not visible) adapted to drive the wheel 310; a balance control system (not visible) adapted to maintain fore-aft balance of the unicycle 310; a casing 320 adapted to cover a portion of the outer rim of the wheel 310; a foot platform 330 projecting horizontally outwardly from each side of the casing 320 for supporting a user of the unicycle; a handle 340 for lifting the unicycle 300; a user presence detection system 350 adapted to detect the presence of a user on or at the handle 340; and a control system (not visible) adapted to control operation of the powered unicycle based on an signal from the user presence detection system 350.

Here, the user presence detection system comprises a proximity sensor 350 integrated into the upwardly facing surface of the 340. The proximity sensor 350 comprises a light sensitive detector that is adapted to detect the existence of an entity in close proximity with the proximity sensor 350 based on the amount (e.g. intensity or luminosity) of light incident on the light sensitive detector.

When a user holds the handle 340 (with at least one of their hands), the light sensitive detector detects the associated drop/decrease in the amount of light incident on the light sensitive detector (caused by the user's hand covering a portion of the light sensitive detector). As a result, the proximity sensor 350, provide an

indication that the user is present at the handle 340 of the unicycle. Based on this indication, the control system is adapted to control operation of the powered unicycle. More specifically, in this example, the control system disables the drive arrangement so that the rotation of the wheel is prevented. Such disabling of the drive arrangement is arranged on the premise/assumption that when the user is holding the handle 340, the user is either lifting/carrying the unicycle 300 or wishes to stop the unicycle 300.

The embodiment of Figure 8 may therefore enable rapid disablement of the unicycle 300 by being adapted to automatically de-activate a drive arrangement when a user dismounts from, or carries, the unicycle 300. Such automatic activation/de-activation may provide power savings, and may also improve device safety by altering operation (e.g. stopping the motor from turning the wheel) when a user picks up the unicycle 300.

Referring to FIG.9, there is depicted a modification to the embodiment of FIG. 8. More specifically, the self-balancing powered unicycle 400 of FIG.9 is similar to that of FIG. 8, except for the difference that the handle 340 does not comprise a proximity sensor integrated therein. Instead, the user presence detection system comprises a proximity sensor 410 integrated into each side of the casing 320. More specifically, each proximity sensor 410 is arranged in a vertically-extending direction above a respective foot platform 330 and employs infrared reflection to detect the existence of an entity in close proximity with it. It will therefore be understood, that each proximity sensor 410 is adapted to detect the presence of a user's lower leg (e.g. foot, ankle and/or calf) next to, adjacent, or contacting the proximity sensor.

When a user stands on the foot platforms 330 (e.g. with each foot supported by a respective foot platform 330), the proximity sensors 410 detect the associated increase in infrared light reflected back to the proximity sensors 410. As a result, the proximity sensors 410, provide an indication that the user is present on the foot platforms 330 of the unicycle 400. Based on this indication, the control system is adapted to control operation of the powered unicycle. More specifically, in this example, the control system enables the drive arrangement so that the rotation of the wheel is permitted. Such enabling of the drive arrangement is arranged on the

premise/assumption that when the user is present on the foot platforms 330, the user wishes to operate the unicycle 400.

Conversely, when a user stands user alights or dismounts from the unicycle 400 (e.g. by intentionally stepping off the foot platform(s) 330 or by falling off), the proximity sensors 410 detect the associated decrease in reflected infrared light reflected. As a result, the proximity sensors 410, provide an indication that the user is not present on the foot platforms 330 of the unicycle 400. Based on this indication, the control system is adapted to disable the drive arrangement so that the rotation of the wheel is not permitted. Such disabling of the drive arrangement is arranged on the premise/assumption that when the user is not present on the foot platforms 330, the user has fallen or stepped away the unicycle 400 and wishes to stop the unicycle 400.

The embodiment of FIG. 9 may therefore enable rapid disablement of the unicycle 400 by being adapted to automatically de-activate a drive arrangement when a user dismounts or falls from the unicycle 400. Such automatic activation/de-activation may provide for improved device safety.

Referring to FIG.10, there is depicted a modified version of the embodiments of FIGS. 8 and 9. More specifically, the self-balancing powered unicycle 500 of FIG.10 is similar to that of FIGS. 8 and 9, except for the difference that the entity presence detection system does not comprise a proximity sensor integrated either in the handle 340 or the casing 320. Instead, the entity presence detection system comprises a signal processing system housed within the casing 320. The signal processing system (such as a processing unit for example) is adapted to process signals from one or more parts of the unicycle 500 in accordance with an algorithm to determine if an entity is present on, at or near a part of the powered unicycle 500.

More specifically, in the embodiment of FIG. 10, the entity presence detection system comprises a processing unit (not visible) that is adapted to process signals from the drive arrangement and/or the balance control system in accordance with a predetermined algorithm. The algorithm is adapted to determine if the signals from the drive arrangement and/or the balance control system exhibit a predetermined

characteristic indicating the presence or non-presence of an entity on, at or near a part of the powered unicycle.

By way of example, the signals from the drive arrangement and/or the balance control system comprise information relating to at least one of: accelerometer data; gyroscope data; motor torque; speed of wheel rotation; and a motor drive voltage.

Using such information, the processing unit is adapted to determine the presence or non-presence of an entity on, at or near a part of, the unicycle 500, by determining if values and/or relationships between values are within a predetermined range for example.

It will be appreciated that variations on the user presence detection systems described above may employ other concepts for determining the presence of a user. For example, in another embodiment, the user presence detection system may comprise a load sensing system adapted to determine a loading applied to at least one part of the powered unicycle (such as a foot platform for example). Such a load sensing system may be adapted to determine at least one of: a deflection of the at least one foot platform; a tensile force applied to the at least one foot platform; and a compressive force applied to the at least one foot platform of the unicycle so as determine a loading applied to the at least one foot platform. If the loading is above a predetermined threshold, it may be determined that a user is supported (e.g. standing on) the at least one foot platform and therefore present on the unicycle for example.

In another example, the entity presence detection system may comprise a vibration sensor adapted to detect a frequency of vibration of at least one part of the powered unicycle. Such a user presence detection system may, for example, be adapted to determine the presence or non-presence of a user by determining if a detected frequency of vibration of at least one part of the powered unicycle is within a predetermined range.

In yet another example, the entity presence detection system may comprise a proximity sensor adapted to detect the proximity of the ground in relation to a part (such as the foot platform(s) or the base of the casing) of the unicycle. The

determined proximity may be used to indicate if the unicycle has left the ground (i.e. is no longer in contact with the ground) due to being lifted or jumping for example. Such a determination may then be used to control the drive arrangement so as to enable, disable or adjust rotation of the wheel for example.

Embodiments may be provided separately from a self-balancing powered unicycle and therefore adapted to be fitted to (or integrated with) an existing self-balancing powered unicycle. In others, embodiments may be provided as a standalone entity presence detection system which can be retro-fitted to a conventional self-balancing powered unicycle. Such a system may also be adapted to be employed or installed in a self-balancing powered unicycle at time of manufacture.

While specific embodiments have been described herein for purposes of illustration, various modifications will be apparent to a person skilled in the art and may be made without departing from the scope of the invention.

For example, although embodiments have been described as employing single concepts or components for detecting the presence of a user on, or at part of, a unicycle, it should be understood that embodiment may employ one or more combinations of such concepts or components. A proximity sensor may therefore be employed in conjunction with a vibration sensor, and the signal provided by these sensors may be used in isolation (for altering unicycle operation in different ways for example), or may be used together (for confirming a signal from one of the sensors for example).

Claims

1. A self-balancing powered unicycle comprising:

a single wheel;

a drive arrangement adapted to drive the wheel;

a balance control system adapted to maintain fore-aft balance of the unicycle device;

at least one foot platform for supporting a user of the unicycle device;

an entity presence detection system adapted to detect the presence of an entity on, at or near a part of the powered unicycle and provide an indication of detected entity presence; and

a control system adapted to control operation of the powered unicycle based on the indication of detected entity presence from the entity presence detection system.

2. The self-balancing powered unicycle of claim 1, wherein the entity presence detection system comprises one or more proximity sensors adapted to detect the existence of an entity in close proximity with the proximity sensor.

3. The self-balancing powered unicycle of claim 2, wherein at least one of the one or more proximity sensors employs at least one of: infrared reflection; ultrasonic sensing; microwave sensing; pressure sensing; temperature sensing; and light detection to detect the existence of an entity in close proximity with the proximity sensor.

4. The self-balancing powered unicycle of claim 2 or 3, further comprising a handle for lifting the unicycle, and wherein the handle comprises at least one of the one or more proximity sensors.

5. The self-balancing powered unicycle of any of claims 2 to 4, further comprising a casing adapted to cover at least a portion of the outer rim of the wheel, and wherein the casing comprises at least one of the one or more proximity sensors.

6. The self-balancing powered unicycle of any preceding claim, wherein the entity presence detection system comprises a load sensing system adapted to determine a loading applied to at least one part of the powered unicycle.

7. The self-balancing powered unicycle of claim 6, wherein the load sensing system is adapted to determine at least one of:

a deflection of the wheel axel;

a force applied to the wheel axel;

a deflection of the at least one foot platform; and

a force applied to the at least one foot platform, so as determine a loading applied to the at least one foot platform of the powered unicycle.

8. The self-balancing powered unicycle of any preceding claim, wherein the entity presence detection system comprises a processing unit adapted to process signals in accordance with an algorithm to determine if an entity is present on, at, or near a part of the powered unicycle.

9. The self-balancing powered unicycle of claim 8, wherein the algorithm is adapted to process signals from the drive arrangement and/or the balance control system.

10. The self-balancing powered unicycle of claim 9, wherein the algorithm is adapted to determine if the signals exhibit a predetermined characteristic indicating the presence or non-presence of an entity on, at or near a part of the powered unicycle.

11. The self-balancing powered unicycle of claim 8, 9 or 10, wherein the signals comprise information relating to at least one of:

casing orientation;

inclination or angle of at least part of the unicycle;

value of a force applied to at least a part of the powered unicycle;

accelerometer data;

gyroscope data;

motor torque;

speed of wheel rotation;
current;
motor temperature;
distance travelled;
time of journey; and
motor drive voltage.

12. The self-balancing powered unicycle of any preceding claim, wherein the entity presence detection system comprises a vibration sensor adapted to detect a frequency and/or amplitude of vibration of at least one part of the powered unicycle.

13. The self-balancing powered unicycle of claim 12, wherein the entity presence detection system is adapted to determine the presence or non-presence of an entity based on if a detected frequency of vibration of at least one part of the powered unicycle is within a predetermined range.

15. An entity presence detection system for a self-balancing powered unicycle, wherein the entity presence detection system is adapted to detect the presence of an entity on, at or near a part of the powered unicycle and provide an indication of detected entity presence.

16. The entity presence detection system of claim 15, wherein the entity presence detection system comprises one or more proximity sensors adapted to detect the existence of an entity in close proximity with the proximity sensor.

17. The entity presence detection system of claim 15 or 16, further adapted to be integrated into a handle of a self-balancing powered unicycle.

18. The entity presence detection system of claim 15, 16 or 17, comprising a load sensing system adapted to determine a loading applied to at least one part of a self-balancing powered unicycle.

19. The entity presence detection system of any of claims 15 to 18, comprising a processing unit adapted to process signals in accordance with an algorithm to

determine if an entity is present on, at, or near a part of a self-balancing powered unicycle.

20. The entity presence detection system of any of claims 15 to 19, comprising a vibration sensor adapted to detect a frequency and/or amplitude of vibration of at least one part of a self-balancing powered unicycle.

21. A self-balancing powered unicycle substantially as herein described above with reference to the accompanying figures.

22. An entity presence detection system for a self-balancing powered unicycle substantially as herein described above with reference to the accompanying figures.

Application No:	GB1415609.5	**Examiner:**	Kris Wojciechowski
Claims searched:	1-22	**Date of search:**	23 February 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 6-11, 15, 18, 19	US2012/175176 A1 (HAMAYA et al.) See figures; paragraphs 0032-42
X	1-3, 5-11, 15, 16, 18, 19	AU2004200265 B2 (AMBROGI et al.) See figures, esp. 8-16; p13, line 25 - p14, line 28; p21, line 16 - p24
X	1-3, 5, 8-11, 15, 16, 19	KR100789906 B (AN) See figures; translated paragraphs 0061-74
X	1, 6-11, 15, 18, 19	US2012/166049 A1 (AKIMOTO et al.) See figures; Paragraphs 0112-140
X	1, 6-11, 15, 18, 19	CN203473073 U (YAN) See figures; EPODOC abstract, AN CN-201320543667-U
X	1, 6-11, 15, 18, 19	JP2011068165 A (AKIMOTO et al.) See figures; translated paragraphs 0082-105
X	1, 6-11, 15, 18, 19	WO2014/064887 A1 (MISAO et al.) See figures; WPI abstract, AN 2014-H84856
X	1-3, 8-11, 15, 16, 19	US2012/243822 A1 (KOBORI et al.) See figures; paragraph 0032-38
X	1, 6-11, 15, 18, 19	WO2012/017335 A1 (NOSENZO et al.) See figures; p2, p3
X	1-3, 8-11, 15, 16, 19	JP2011164040 A (DEO et al.) See figures; WPI abstract, AN 2011-K82960

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of	P	Document published on or after the declared priority date but before the filing date of this invention.

	same category.		
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

B62J; B62K

The following online and other databases have been used in the preparation of this search report

EPODOC & WPI

International Classification:

Subclass	Subgroup	Valid From
B62K	0001/00	01/01/2006