VEHICLE STABILIZING SYSTEM HAVING PIVOTAL SUPPORT

Technical Field

The present invention pertains to a balancing personal vehicle having a support for a human subject, the support being pivotable in order to allow the subject to be supported at a desired angle with respect to ground contacting elements of the vehicle.

Background of the Invention

Personal vehicles may be self-propelled and user-guidable, and, further, may entail stabilization in one or both of the fore-aft or left-right planes, such as when no more than two wheels are in ground contact at a time. Vehicles of this sort may be operated in a mode in which motion of the vehicle, including acceleration (both linear and turning), is controlled partially or entirely by leaning of the vehicle as caused by a subject riding the vehicle. Several such vehicles are described in U.S. Patent no. 5,971,091 which is incorporated herein by reference.

Such balancing vehicles may lack static stability. Referring, for example, to Fig. 1A, wherein a prior art personal transporter is shown and designated generally by numeral **18**, a subject **10** stands on a support platform **12** and holds a grip **14** on a handle **16** attached to the platform **12**, so that the vehicle **18** of this embodiment may be operated in a manner analogous to a scooter. A control loop may be provided so that leaning of the subject results in the application of torque to wheel **20** about axle **22** thereby causing an acceleration of the vehicle. Vehicle **18**, however, is statically unstable, and, absent operation of the control loop to maintain dynamic stability, subject **10** will no longer be supported in a standing position and will fall from platform **12**. Another prior art balancing vehicle is shown in Fig. 1B and designated generally by numeral **24**. Personal vehicle **24** shares the characteristics of vehicle **12** of Fig. 1A, namely a support platform **12** for supporting subject **10** and grip **14** on handle **16** attached to platform **12**, so that the vehicle **18** of this embodiment may also be operated in a manner analogous to a scooter. Fig. 2 shows that while vehicle **24** may have clusters **26** each having a plurality of wheels **28**, vehicle **24** remains statically unstable and,

absent operation of a control loop to maintain dynamic stability, subject **10** will no longer be supported in a standing position and may fall from platform **12**.

Summary of the Invention

In accordance with a preferred embodiment of the invention, there is provided a device for transporting a human subject over a surface. The device has a platform defining a fore-aft plane that supports a payload including the human subject. The device also has a ground-contacting module that includes a ground-contacting member movably coupled to the platform. The platform and the ground-contacting module are components of an assembly, and the position of the center of gravity of the assembly is defined with respect to the ground-contacting member. The device also has a support for supporting the subject, where the support is coupled to the platform in such as manner as to permit variation in the fore-aft plane of the position of the center of gravity. Furthermore, the device has a drive, coupled to the ground contacting module, for delivering power to the ground-contacting module in a manner responsive to the position of the center of gravity.

In accordance with alternate embodiments of the present invention, the support includes a seat. The support may be coupled to the platform at a pivot oriented to allow motion of the support about an axis substantially transverse to the fore-aft plane. The device may have a handle, affixed to the platform, having a grip at approximately waist height of the subject, so that the device may be operated in a manner analogous to a scooter. The ground-contacting module may be characterized by a region of contact with the ground and the support may have an articulated member, biased for supporting a portion of the weight of the subject, and the support may have a region of local stability substantially above the region of contact with the ground of the ground-contacting module.

In accordance with a further embodiment of the invention, there is provided a device for carrying a user, wherein the device has a platform and a user support having a position defined with respect to the platform and coupled to the platform in such a manner that the user may vary the position of the support with respect to the platform in the course of normal operation of the device. The device also has a motorized drive that propels the platform over an underlying surface through motion of at least one ground-

contacting member and a controller, coupled to the motorized drive, for governing the operation of the motorized drive at least in response to the position of the user support.

In accordance with yet a further embodiment of the invention there is provided a device for conveying a seated user. The device has a platform for supporting a payload including the seated user, a ground-contacting module mounted to the platform that propels the platform with respect to an underlying surface, and a drive, coupled to the ground-contacting module, for delivering power to the ground-contacting module in a manner controlled solely by leaning of the user.

Brief Description of the Drawings

The invention will be more readily understood by reference to the following description, taken with the accompanying drawings, in which:

FIG. **1A** is a side view of a prior art dynamically balancing vehicle of the type in which an embodiment of the invention may be advantageously employed;

FIG. **1B** is a side view of a further prior art dynamically balancing vehicle of the type in which an embodiment of the invention may be advantageously employed;

FIG. **2** is a side view of a dynamically balancing vehicle having an articulated pivotable support in accordance with an embodiment of the invention;

FIG. **3** is a side view of the dynamically balancing vehicle of Fig. 2 showing the articulated pivotable support in a partially folded configuration; and

FIG. **4A** is a side view of a dynamically balancing vehicle showing an articulated pivotable support in a further embodiment of the present invention;

FIG. **4B** is a further side view of the embodiment of Fig. 4A showing two positions of the pivotable support;

FIG. **5A** is a side view of a pivotable support having a central equilibrium position in accordance with a further embodiment of the present invention; and

FIG. **5B** is a further side view of the embodiment of Fig. 5A showing detail of a cam-follower arrangement.

Detailed Description of Preferred Embodiments

Referring to Fig. 1A, prior art balancing vehicle **18** does not provide a seat for

the subject **10** using the vehicle. The subject stands on a platform **12** and holds a grip **14** on handle **16** attached to platform **12**, so that the vehicle of this embodiment may be operated in a manner analogous to a scooter. The pitch of the vehicle may be sensed and compensated for in the control loop, so that if the subject leans forward, the vehicle will move forward, and similarly, leaning in other directions may cause corresponding motion of the vehicle. Accordingly, a forward lean will cause forward movement; a backward lean will cause backward movement. Appropriate force transducers may be provided to sense leftward and rightward leaning and related controls provided to cause left and right turning as a result of the sensed leaning. The leaning may also be detected using proximity sensors. Similarly, the vehicle of this embodiment may be equipped with a foot- (or force-) actuated switch to activate the vehicle, in such a manner that the switch is closed so as to power the vehicle automatically when the subject stands on the platform **12**.

Referring now to Fig. 2, a personal vehicle **30** is shown of the type in which pitch of the vehicle may be sensed and compensated for by application of torque to one or more wheel **32** (or other ground-contacting members) by operation of a control loop (not shown) and wheel actuator (not shown), so that if subject **10** leans forward, the vehicle is caused to move forward. It is to be understood that platform **12** is not necessarily coupled directly to wheel **32**. Tilting of the vehicle is not necessarily canceled during ordinary operation of the vehicle, so that sustained motion and sustained acceleration may be achieved. In accordance with an embodiment of the present invention, a seat **34** is provided for supporting a portion of the weight of subject **10**. Subject **10** may still vary the position of his center of gravity, and the position of the center of gravity **36** of the combination of vehicle **30** and subject **10** while seat **34** continues to support a portion of the weight of the subject by virtue of the pivotability of seat **34** with respect to platform **12**.

It is to be understood that within the scope of the present invention, as described herein and as claimed in any appended claims, wheel **32** may rotate about a single axle, or, alternatively, about an axis that may vary in orientation, in the manner of a uniball.

Seat **34** may be coupled to platform **12** by any of a variety of mechanisms. In accordance with a preferred embodiment of the present invention, seat **34** is coupled to

platform **12** via link **38**, itself pivotally coupled to platform **12**, and coupled to seat **34** at knee joint **40**. The articulated support comprising seat **34** and link **38** may be biased by a spring arrangement (not shown) or its equivalent so as to counter the weight of the subject. Figure 3 shows seat **34** depressed at knee joint **40** with respect to link **38**. Additionally, pivot **42** is shown coupling link **38** to support platform **12** in a manner as to constrain link **38** to fore-aft motion about an axis substantially transverse to the fore-aft plane. The spring arrangement (not shown) may include any means, such as a coil spring or a gas spring, known for biasing the support mechanism for supporting some fraction of the weight of the subject. Additionally, mechanisms known in the art for providing for translation of seat **34** in a fore-aft direction for shifting the weight of subject **10** with respect to ground-contacting member **32** are within the scope of the present invention.

An alternative to the articulating folding seat of the embodiment of Fig. 3 is described with reference to Fig. 4A. A balancing personal vehicle **44** is shown in which seat **34** may be pivoted with respect to support platform **12** by means of a seat support mechanism designated generally by numeral **46**. Seat support **46** has two substantially linear members **48** which pivot in about pivots **50** through which linear members **48** are coupled to platform **12**. Linear members **48** are coupled to seat **34** at pivots **52**. A subject seated on seat **34** may shift her weight, and thereby the center of gravity of the combination of vehicle and subject, by moving seat **34** in a fore-aft direction. Fig. 4B shows the articulating folding seat of Fig. 4A in two positions: the position designated **54** places the center of gravity of the vehicle, including the rider, substantially above the region of contact of the ground-contacting member **20** (shown in Fig. 4A) with the ground. Seat **34** may also be folded up toward handle **16** as in the position designated by numeral **56**. In the embodiment shown in Figs. 4A and 4B, seat **34** is highest, and thus possesses the greatest potential energy, in central position **54**.

Referring now to Fig. 5A, in accordance with other embodiments of the present invention, stability is provided by ensuring that the central position of the seated user, substantially above axle **22**, is a stable position, i.e., a position characterized by a local minimum of potential energy. Thus, with respect to the central position designated by numeral **54**, seat **34** is displaced further from platform **12**, and thus higher above level

ground, as seat **34** is moved by virtue of the rider moving in either a forward direction **60** or an aft direction **62**. In accordance with the embodiment depicted in Fig. 5A, seat **34** is supported by a substantially trilateral arrangement **64** of links. Arm **66** pivots about a pivot point **68** fixed with respect to platform **12**, while link **70** couples arm **66** to seat **34**. Link **72**, substantially parallel to link **70**, supports seat **34** in a substantially horizontal orientation in its central position **54**. The third side of trilateral arrangement **64** is formed by link **74**. Link **74**, as shown in greater detail in Fig. 5B, may be a rigid member or a suspension member, as shown, containing a gas spring **76** which serves to cushion seat **34** with respect to vibration transmitted from the road surface through platform **12**. Link **74** is coupled to cam follower **78** which rides on cam surface **80** in such a manner as to provide a well **82** of stability at the center of motion of seat **34**. If seat **34** moves fore or aft, cam follower **78** is driven up cam **80**, thereby increasing the height of seat **34** relative to platform **12** relative to its position of stability at the center. This reduces the effort required of the rider to maintain a centered body position, thereby advantageously allowing the rider to maintain a more relaxed position and momentarily to remove his/her hands from the handlebar.

It is to be understood that other mechanical configurations providing for seat **34** to rise as seat **34** is moved either forward or aft of its central position **54** wherein the center of gravity of the vehicle and rider is substantially over the region of contact of the vehicle with the ground are within the scope of the present invention as claimed in the appended claims.

The described embodiments of the invention are intended to be merely exemplary and numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in the appended claims.

WE CLAIM:

1. A device for transporting a human subject over a surface, the device comprising:

   a. a platform defining a fore-aft plane, the platform supporting a payload including the human subject;

   b. a ground-contacting module, including a ground-contacting member movably coupled to the platform, the ground contacting member characterized by a region of contact with the ground, the platform and the ground-contacting module being components of an assembly having a center of gravity, the center of gravity having a position defined with respect to the ground-contacting member;

   c. a support for supporting the subject, the support coupled to the platform in such a manner as to permit variation of the position of the center of gravity in the fore-aft plane by a movement of the support by the subject with respect to the platform; and

   d. a drive, coupled to the ground-contacting module, for delivering power to the ground-contacting module in a manner responsive to the position of the center of gravity

2. A device in accordance with claim 1, wherein the support includes a seat.

3. A device according to claim 1, wherein the support is coupled to the platform at a pivot oriented to allow motion of the support about an axis substantially transverse to the fore-aft plane.

4. A device according to claim 1, further comprising a handle, affixed to the platform, having a grip at approximately waist height of the subject, so that the device may be operated in a manner analogous to a scooter.

5. A device according to claim 1, wherein the support includes an articulated member, biased for supporting a portion of the weight of the subject.

6. A device according to claim 1, wherein the support has a position of local stability substantially above the region of contact with the ground of the ground-contacting module.

7. A device for carrying a user, the device comprising:

   a. a platform;

   b. a user support including a seat having a position defined with respect to the platform and coupled to the platform in such a manner that the user may vary the position of the support with respect to the platform in the course of normal operation of the device while seated;

   c. a motorized drive that propels the platform over an underlying surface through motion of at least one ground-contacting member; and

   d. a controller, coupled to the motorized drive, for governing the operation of the motorized drive at least in response to the position of the user support.

8. A device according to claim 7, wherein the position of the support with respect to the platform may be varied by leaning of the user.

9. A device according to claim 1, wherein the movement of the support by the subject with respect to the platform occurs both fore and aft of any line extending vertically above the region of contact with the ground.

10. A device according to claim 7, wherein the device is unstable with respect to tipping when the motorized drive is not powered.

AMENDED SHEET