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- | | | |
|-------------|--------|---------------|
| 3,888,334 A | 6/1975 | Mack |
| 3,954,282 A | 5/1976 | Hege |
| 4,026,571 A | 5/1977 | Vereyken |
| 4,077,648 A | 3/1978 | Seul |
| 4,134,481 A | 1/1979 | Calderazzo |
| 4,333,664 A | 6/1982 | Turner et al. |
| 4,456,276 A | 6/1984 | Bortolin |
- (Continued)

(Continued)

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- FOREIGN PATENT DOCUMENTS

- | | | | |
|----|------------|----|--------|
| WO | 2006002577 | A1 | 1/2006 |
| WO | 2006059003 | A1 | 6/2006 |
| WO | 2017132658 | A1 | 8/2017 |

- ## OTHER PUBLICATIONS

- Search Report and Written Opinion for International Application
No. PCT/US17/015596 dated May 26, 2017.

(Continued)

Primary Examiner — Kevin Hurley

- (63) Continuation-in-part of application No. 17/011,558, filed on Sep. 3, 2020, which is a continuation-in-part of application No. 16/522,865, filed on Jul. 26, 2019, now Pat. No. 10,858,065.

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B62K 3/00 (2006.01)

- (57) **ABSTRACT**

- (52) **U.S. Cl.**
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(2013.01)

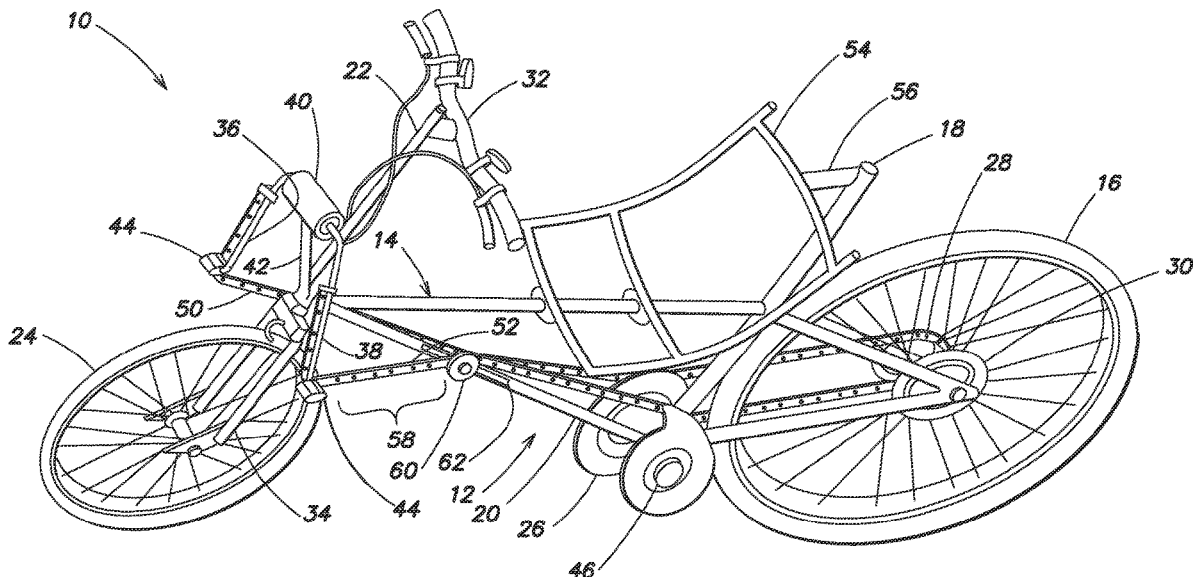
- (58) **Field of Classification Search**
CPC . B62M 1/24; B62M 1/28; B62M 1/30; B62K
3/005
See application file for complete search history.

- (56)
- References Cited**

U.S. PATENT DOCUMENTS

- | | | | |
|-----------|---|---------|-----------|
| 608,674 | A | 8/1898 | Harshner |
| 2,141,967 | A | 12/1938 | Ball, Jr. |
| 3,039,790 | A | 6/1962 | Trott |

- 20 Claims, 4 Drawing Sheets**



References Cited

4,574,649	A	3/1986	Seol	
4,630,839	A	12/1986	Seol	
4,659,098	A	4/1987	Jacobson	
4,666,173	A	5/1987	Graham	
4,846,488	A	7/1989	Szadkowski	
4,878,684	A	11/1989	Lemle	
5,035,678	A	7/1991	Hageman	
5,272,928	A	12/1993	Young	
5,290,054	A	3/1994	Po	
5,496,051	A *	3/1996	Farmos	B62M 1/24 280/251
5,527,246	A	6/1996	Rodgers	
5,584,494	A	12/1996	Krumm	
5,732,963	A	3/1998	White	
5,915,710	A	6/1999	Miller	
5,979,922	A	11/1999	Becker et al.	
6,000,707	A	12/1999	Miller	
6,007,083	A	12/1999	Currie	
6,173,981	B1	1/2001	Coleman	
6,209,900	B1	4/2001	Yoshizawa	
6,237,928	B1	5/2001	Islas	
6,336,646	B1	1/2002	Bernardini	
6,340,067	B1	1/2002	Fujiwara et al.	
6,412,802	B1	7/2002	Kugel et al.	
6,730,003	B1	5/2004	Phillips	
7,048,290	B2	5/2006	Paquette	
7,416,203	B2	8/2008	Tollhurst	
7,497,453	B2	3/2009	Fan	
7,559,264	B2	7/2009	Qian	
7,753,387	B2	7/2010	Wei	

8,157,281	B2	4/2012	Wang	
8,215,654	B1	7/2012	Leser	
8,955,861	B1	2/2015	Rasiah	
8,967,022	B2	3/2015	Beard	
8,979,107	B2	3/2015	Lin	
9,221,514	B2 *	12/2015	Scolari	B62M 9/04
9,688,349	B2	6/2017	Thompson	
10,435,102	B2	10/2019	White	
2002/0053779	A1	5/2002	Fujiwara et al.	
2002/0074788	A1	6/2002	Fujiwara et al.	
2003/0122330	A1	7/2003	Nelson	
2003/0193160	A1	10/2003	Mehmet	
2006/0046884	A1	3/2006	Estergomny	
2007/0228687	A1	10/2007	Parker	
2010/0089193	A1	4/2010	Martin	
2010/0320718	A1 *	12/2010	Buchberger	F16H 19/0659 280/221
2011/0049830	A1	3/2011	Hung	
2011/0057411	A1	3/2011	Scolari et al.	
2011/0115190	A1	5/2011	McIsaac	
2011/0266768	A1	11/2011	Kohlheb et al.	
2014/0210179	A1	7/2014	Sprague	
2014/0367940	A1	12/2014	Lin	
2015/0076787	A1	3/2015	Kipnis	
2017/0217536	A1	8/2017	Kipnis	
2018/0127052	A1	5/2018	Scarborough	
2019/0031280	A1	1/2019	Kipnis	

Partial Supplementary European Search Report for EP 17745075.6
dated Oct. 31, 2019.

* cited by examiner

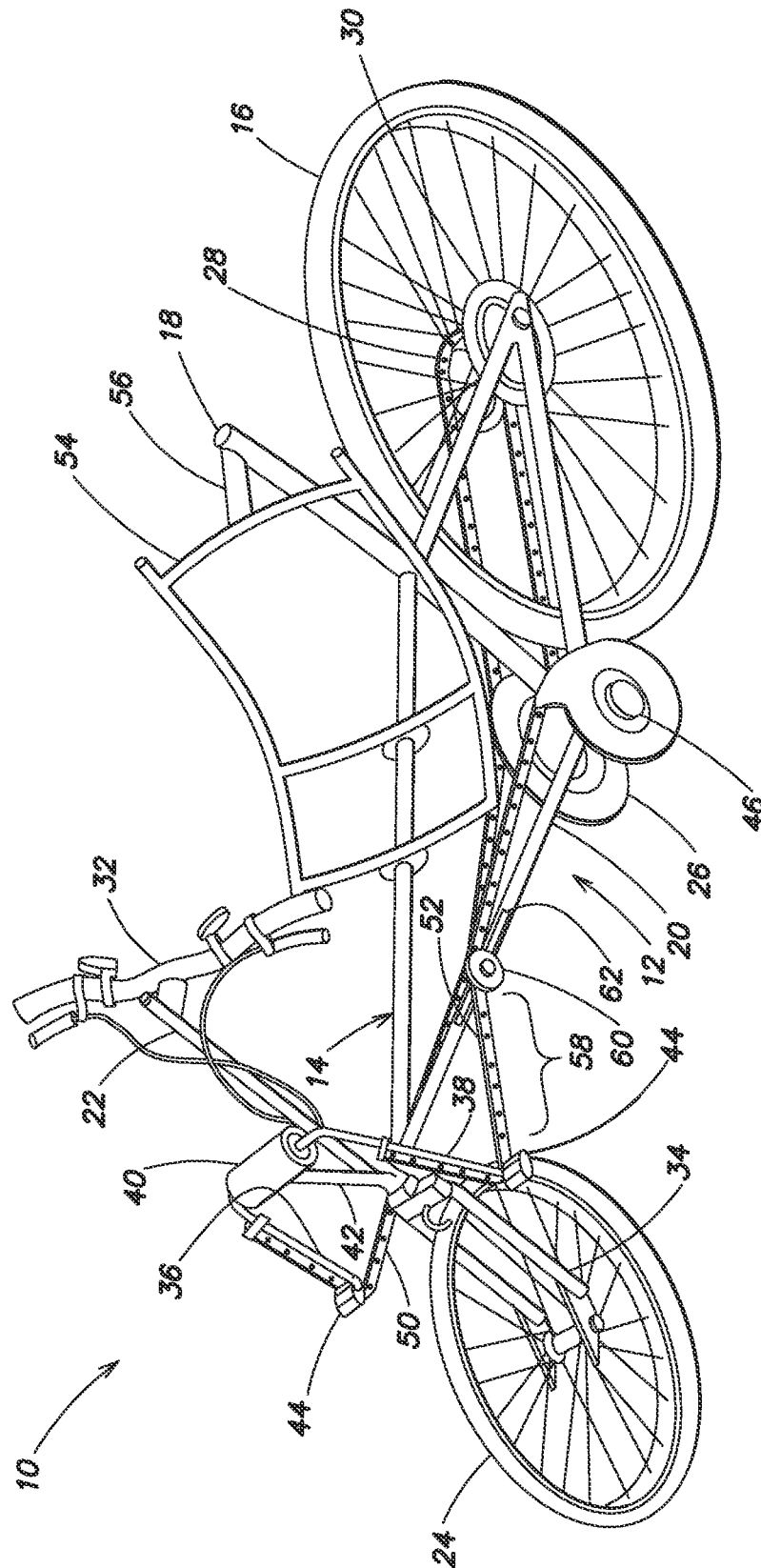


FIG. 1

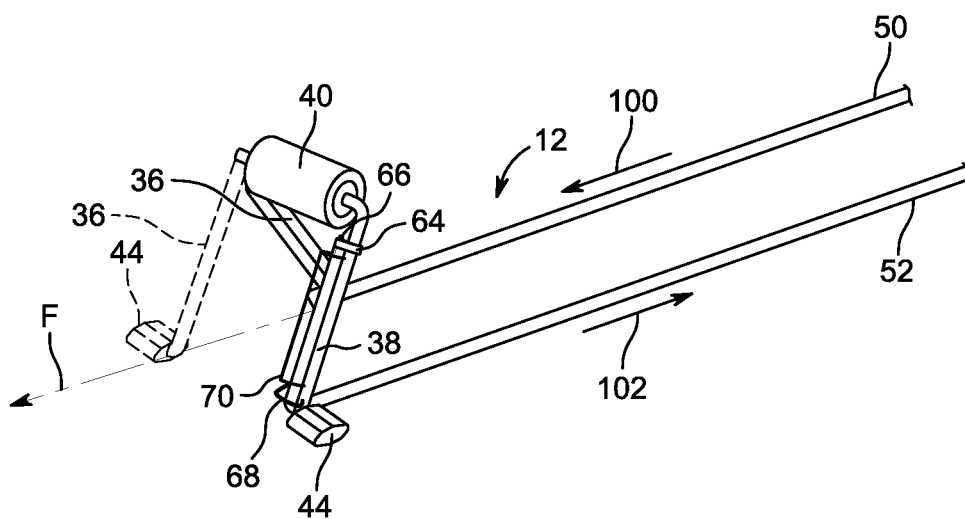


FIG. 2

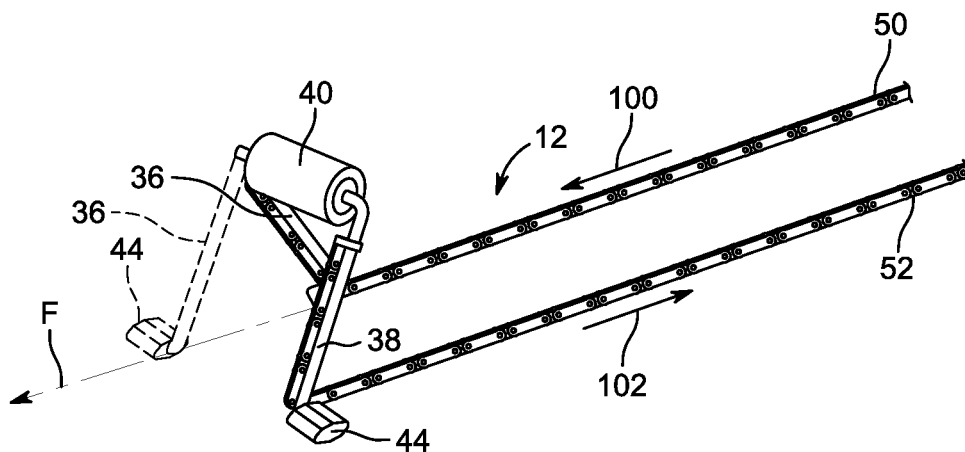


FIG. 3

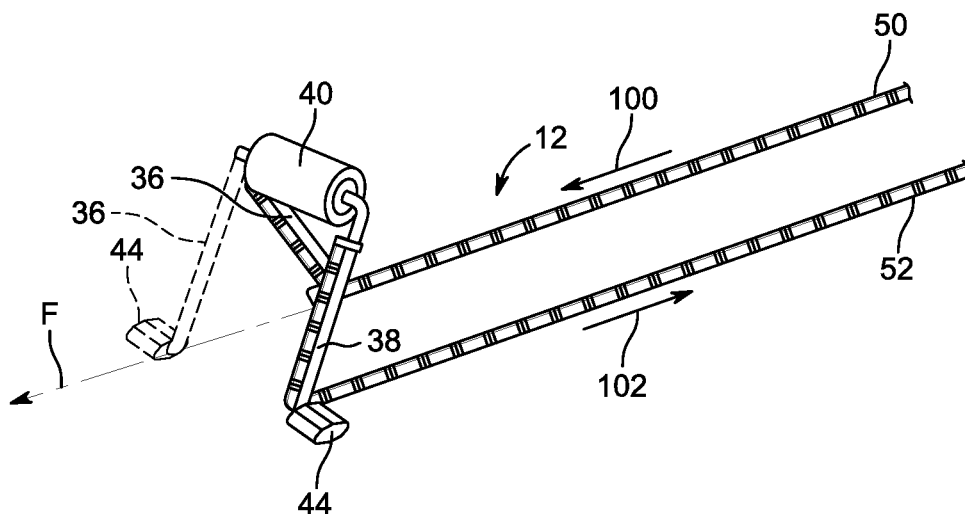
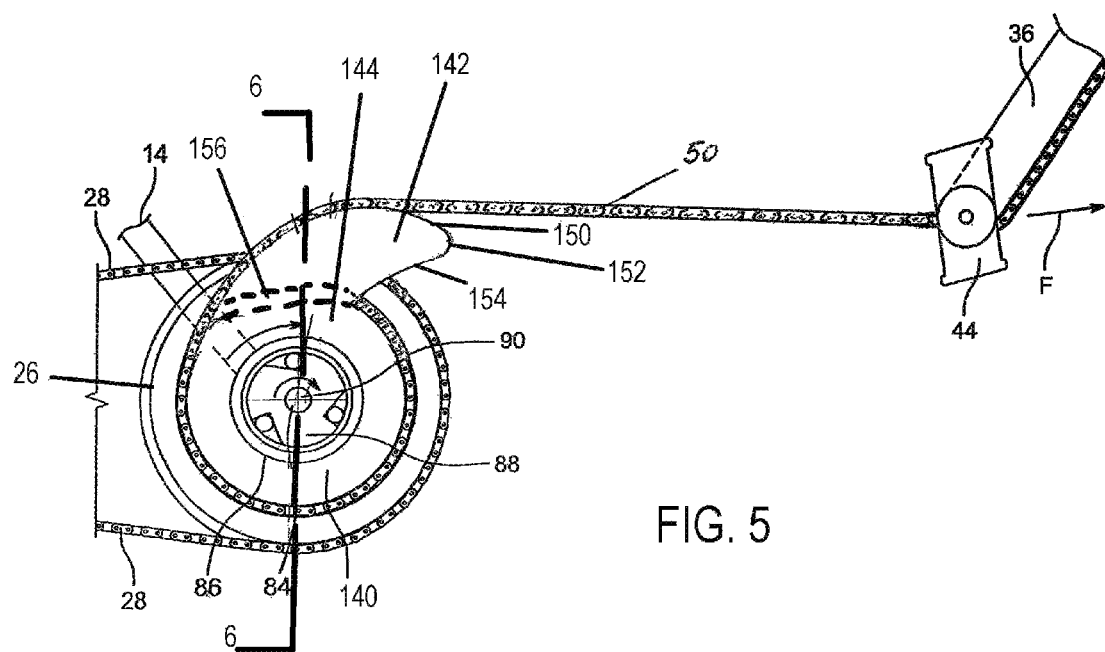


FIG. 4



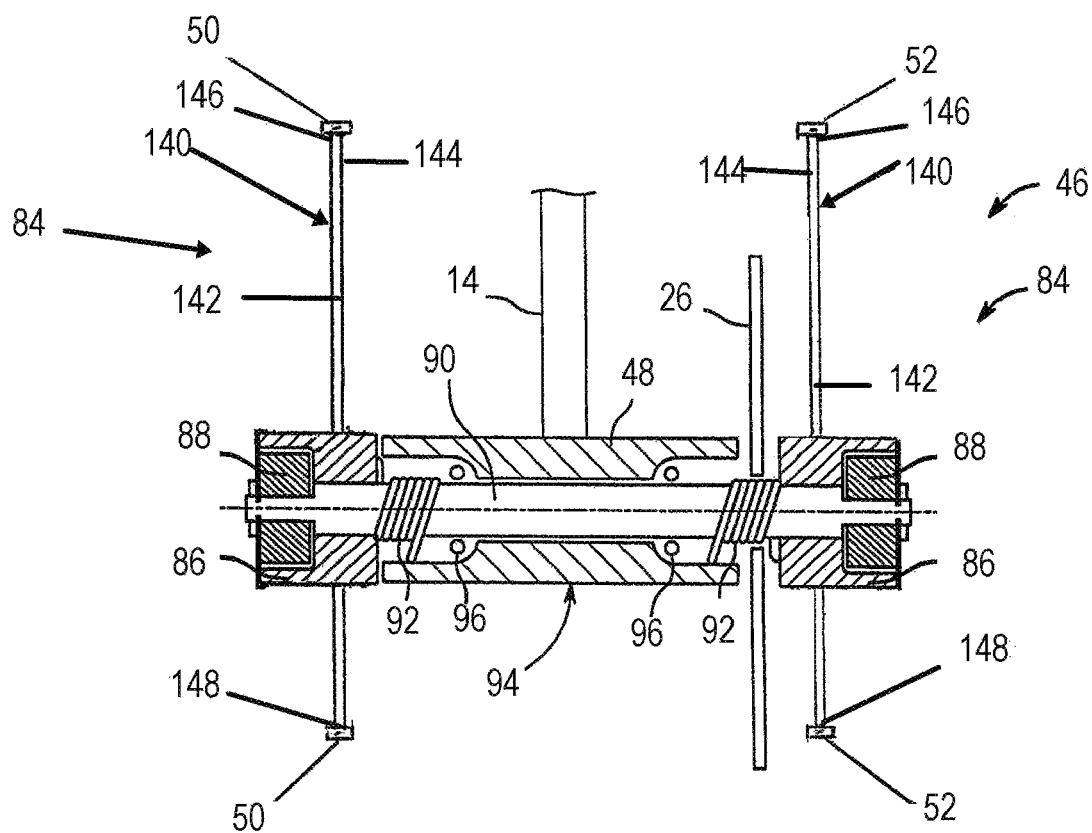


FIG. 6

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BICYCLE WITH FORCE-INCREASING ACTUATION SYSTEM

FIELD OF THE INVENTION

This invention is generally related to recumbent human-powered vehicles such as bicycles, tricycles and other multi-wheel variants that are propelled by a reciprocating thrust motion of the rider using a linear drive mechanism connected by a flexible power link to an overrunning clutch transmission with returning springs. The human-powered vehicle is propelled with the use of pedals which are positioned approximately above and on either side of the front wheel to create a short wheel base in the human-powered vehicle, with the seat located between the front and rear wheels. The human-powered vehicle may be propelled with the thrust motion of one leg, both legs in an alternating motion such as a typical crank-shaft bicycle, or with the use of both legs simultaneously.

The present invention also relates to a transmission system for a vehicle that has an asymmetrically-shaped drum as part of an actuation system which provides increased rotational force when using the vehicle.

BACKGROUND OF THE INVENTION

Prior art of interest to the field of the invention is as follows:

Recumbent human-powered vehicles such as bicycles and tricycles and human-powered vehicles with linear drivers are known in the prior art. Some examples of such art are found in U.S. Pat. Nos. 4,878,684; 5,979,922; 5,732,963; 5,290,054; 5,915,710; 7,048,290 B2; and WO 2006/002577. Indeed, various bicycle systems and rider positions have been proposed in the art in an effort to provide a rider position that is both comfortable and utilitarian. For example, rectilinear pedal drive systems having two drive chains and an upright rider position are known in the art. Such a system has a separate, vertically-oriented structure mounted to a bicycle frame for supporting and guiding the pedals when in an upright riding position. Recumbent human-powered vehicles with pivotally mounted pedals movable along an arcuate motion have been proposed. Other prior pedal drive systems use interconnected pedals that allow only alternating pedal motion, while other systems allow for both pedals to move forward and rearward together. For reasons provided below, these examples of human-powered vehicles are deficient when compared to the present invention.

U.S. Pat. No. 4,878,684 ("the '684 patent") discloses a recumbent bicycle with a crank transmission, which has certain disadvantages when compared to the present invention, including, for example, lower efficiency, crank kick-backs and crank getting stuck. The recumbent bicycle of the '684 patent has the pedals in front of the seat, with both the seat and pedals being positioned along the frame of the bicycle between the rear and front wheels. Due to this positioning, the '684 patent bicycle has a wheel base that is substantially longer than one of a conventional upright bicycle. The increased length and resultant weight make such a bicycle difficult to maneuver and slower than either conventional bicycles or human-powered vehicles disclosed in the present invention. A shorter wheel base and lighter human powered vehicles are desirable. In addition, as explained below, the crank transmission of the '684 patent provides only about 24% or less muscle efficiency. Such inefficiency is too low, especially for a larger, heavier

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vehicle described in the '684 patent. To overcome the disadvantages of crank-operated recumbent bicycles such as those described in the '684 patent, it is desirable to utilize linearly reciprocating pedals positioned in front of the front wheel of the human-powered vehicle, as disclosed below.

U.S. Pat. No. 5,979,922 ("the '922 patent") describes a recumbent bicycle with a linear drive mechanism and a partially linearly reciprocating pedal motion; however, when compared to the present invention, the bicycle of the '922 patent has many disadvantages. First, due to the length of the pedal sliders described in the '922 patent, the wheel base of the resulting bicycle is substantially longer than that of a conventional bicycle. Thus, similar to the '684 patent, the bicycle of the '922 patent is both long and heavy, and suffers from the same disadvantages as the '684 patent bicycle. Moreover, the design described in the '922 patent has a potential problem with stability and requires retractable stabilizer wheels, which make this design dangerous and impractical for most riders. Indeed, the aforementioned disadvantages are typical of most recumbent bicycles known in the art. The presently described invention addresses this known problem, among others, with a wheel base potentially equal to or only slightly longer than a conventional upright bicycle. Such a design, coupled with the novel drive mechanism proposed herein, eliminates one or more of the problems associated with a long wheel base. Second, the recumbent bicycle of the '922 patent does not allow for independent pedal motion wherein the rider chooses simultaneous or alternating pedal motion, which may be powered by a rider having only one leg. Finally, the '922 patent lacks in power efficiency provided with the use of the novel linear drive mechanism connected by a flexible power link to a double overrunning clutch transmission with returning springs.

U.S. Pat. Appln. Publ. No. 20150076787 (Kipnis) describes a recumbent human-powered vehicle is propelled by a reciprocating thrust motion using a linear drive mechanism connected by flexible power links to a double overrunning clutch transmission with returning springs. The vehicle has a wheel base approximately that of a conventional upright bicycle and does not utilize a crank transmission. The vehicle may be propelled with alternating, single or simultaneous leg motion with the use of pedal sliders positioned for independent pendulum-type oscillation. The linearly reciprocating pedals are rotationally linked to the transmission portion of the linear drive mechanism through a pair of flexible power links so as to transfer power from the pedals to the transmission, which includes a pair of overrunning clutches connected to the main chain axis allowing to transmit the moving force to the main chain axis. The overrunning clutches return back to idle mode with the use of returning springs.

Additional prior art references accumulate many of the problems described above. These include U.S. Pat. Nos. 4,574,649, 4,846,488, 5,272,928, 5,290,054, 5,732,963, 5,915,710, 6,173,981, and 7,048,290.

Therefore, a need in the art exists for an efficient recumbent human-powered vehicle with a wheel base approximately that of a conventional upright bicycle, low weight and convenient seating and steering, and that may be operated with a simultaneous thrust motion of both legs, alternative thrusts of either leg, or with one leg only. A further need in the art exists for a human-powered vehicle as an alternative to automobiles and other forms of transit. The present invention fulfills these and other needs by providing, as one embodiment, a short wheel base recumbent human-powered vehicle propelled by a reciprocating thrust motion

of the operator using a linear drive mechanism connected by a flexible power link to a double overrunning clutch transmission with returning springs.

OBJECTS AND SUMMARY OF THE INVENTION

An object of at least one embodiment of the present invention is to provide a recumbent human-powered vehicle propelled by a reciprocating thrust motion of the operator using a linear drive mechanism connected by flexible power links to a double overrunning clutch transmission with returning springs. The human-powered vehicle is propelled with the use of pedals, which are positioned approximately above and on either side of the front wheel to create a short wheel base, approximately the same or slightly larger than that of a conventional upright bicycle, with the seat located between the front and rear wheels.

The human-powered vehicle generally comprises a frame supporting a rider in a substantially recumbent position, a driven wheel rotatably mounted on the frame, a drive gear for driving the driven wheel, left and right pedals mounted on the front of the frame in front of the steering column, with the right and left pedals reciprocally traveling in a substantially horizontal rectilinear or curved path. The top extremities of a pair of pedal sliders are positioned for independent pendulum-type oscillation (swinging forward and backward) in a pedal-slider bracket, which is connected to a frame through a front bracket. The linearly reciprocating pedals are attached to the lower extremity of the pedal sliders and are rotationally linked to the linear drive mechanism through a pair of flexible power links such as chains or flexible cords so as to transfer power from the pedals to the drive mechanism.

The linear drive mechanism is located between the wheels, and the recumbent seat is located on the beam in front of or between the rear wheel(s) and the steering column. The drive mechanism is connected to the vehicle main chain axis drive/transmission, which is connected to the frame and includes a pair of sprocket wheels connected a pair of overrunning clutches allowing transmission of the moving force to the main chain axis and returning back as overrunning clutches in idle mode.

Each overrunning clutch includes a drum fixed to an outer ring with one end region of the power link being connected to the drum and the other end region being connected to the respective pedal slider. Each drum includes a groove in which the power link coils over itself. By coiling over itself, the power link is able to provide variable degrees of force transmission dependent on a vertical location at which the power links separates from the drum.

Alternatively or additionally, each drum includes an outer power-link engaging surface over which the power link passes, and the drum has a circular portion and a fin extending radially outward from the circular portion. The power link passes over the fin and the circular portion and has a free portion between the fin and the pedal slider. The fin may be above the circular portion so that the power link has a free portion between a separation point at which it separates from contact with the fin and the pedal slider and which free portion is above the drum. The outer power link-engaging surface or edge of the fin aligns with an outer power link-engaging surface or edge of the circular portion to provide a contiguous path for the power link over the drum.

Rollers are optionally arranged on the frame to guide the power links, each in a substantially horizontal plane in a portion between the roller and the respective pedal slider.

To return the flexible power links and pedals back to a working position, the flexible power links are connected to a pair of springs, which are connected to the vehicle frame. For example, the flexible power links may be returned to original or working position by spiral torsion springs, which are also connected to the flexible power links and the vehicle frame.

The pedals execute a back-and-forth motion between a fully extended and a contracted position. Unlike other recumbent human-powered vehicles, the present invention does not utilize a crank transmission and may be propelled with the thrust motion of one leg, both legs in an alternating motion such as a typical bicycle using a crank mechanism, or with the use of both legs simultaneously.

The human-powered vehicle of the present invention has a very efficient power transfer to the wheels, thereby increasing the speed of the vehicle as compared to typical recumbent bicycles and tricycles, permitting a greater speed and distance of travel, and allowing to carry additional weight, such as, for example, extra passengers. Typical crank-operated human-powered vehicles such as bicycles and tricycles are capable of only 24% muscle efficiency as compared to the novel linear drive and double-overrunning clutch transmission utilized in the present invention, which use approximately 90% or higher muscle efficiency. The increased efficiency, relatively lighter weight, comfort and ease of steering of the human-powered vehicle described herein, make it as an alternative to fuel-consuming vehicles for local travel and transport of lighter weight loads.

A particular feature of the recumbent position and frame of the vehicle described herein is a riding position that, compared with the upright seated position, affords more efficient and comfortable propulsion, where muscle stress may be more readily alternated among muscles groups of both the front and back of the body. The recumbent position of the seat in the present invention offers additional medical benefits that are well-known and described in the art of recumbent cycling, such as, for example, decreased pressure on the groin area.

Due to the relatively short wheel base of embodiments of a bicycle in accordance with the present invention and its unique linear drive transmission, the human-powered vehicle of the present invention is generally capable of attaining speeds substantially higher than those of conventional crankshaft-operated recumbent bicycles and tricycles. The combination of the design with a short wheel base and the linear drive mechanism described herein also permits the user of the vehicle to propel heavier loads, such as additional passengers, groceries, and other weight.

Further objects and advantages of this invention will become apparent from a consideration of the included figures with corresponding description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, wherein like reference numerals identify like elements, and wherein:

FIG. 1 is a perspective view of an embodiment of the present invention.

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FIG. 2 is a perspective view of the linear drive mechanism and a particular embodiment of the flexible power link, namely, a vinyl-coated metal cord, used in the present invention.

FIG. 3 is a perspective view of the linear drive mechanism and a particular embodiment of the flexible power link, namely, a metal chain, used in the present invention.

FIG. 4 is a perspective view of the linear drive mechanism and a particular embodiment of the flexible power link, namely, a belt, used in the present invention.

FIG. 5 is a left side view of an embodiment of the transmission and linear drive mechanism of the present invention (utilizing an eccentric shaft and a metal chain as a flexible power link).

FIG. 6 is a cross-sectional view taken along the line 6-6 of FIG. 5.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the accompanying drawings wherein the same reference numbers refer to the same or similar elements, FIG. 1 shows a recumbent bicycle 10 in accordance with the invention having a double-stroke linear drive mechanism 12 integral with a bicycle frame 14. The recumbent bicycle 10 has many of the standard components found in typical bicycles, such as a rear wheel 16, top tube 18, lower tube 20, steering column 22, front wheel 24, main drive sprocket or sprocket plate 26, main drive chain 28, rear wheel drive sprocket 30, adjustable handlebar 32, and front fork 34. Bicycle 10 may include alternative or other components known to be used on bicycles as long as they do not interfere with the mechanism 12.

Bicycle 10 is provided with a right pedal slider 36 and left pedal slider 38, with upper ends of the pedal sliders 36 and 38 joined to a pedal slider bracket 40 of a pedal slider bracket holder 42 of the frame 14 to create a pendulum-type oscillation movement (with the pedal sliders 36, 38 being independently swingable). A respective pedal 44 is attached to the lower end of each of the pedal sliders 36 and 38. Bracket holder 42 serves to provide a fixed pivot axis about which the pedal sliders 36, 38 swing. It may be part of the frame 14 or a separate part and then attached to the frame 14.

An alternative bracket holder 42 is shown in FIG. 15 of U.S. patent application Ser. No. 17/011,558 and may be used herein. The '558 application is incorporated by reference herein for its disclosure of the alternative bracket holder 15 shown in FIG. 15 thereof and for all of its other disclosure. The alternative bracket holder 42 provides for an adjustment in the position of the bracket holder 42, and thus the pedal slider bracket 40.

Drive mechanism 12 includes an overrunning clutch system 46, which is positioned for rotation in connection with a transmission bracket 48 mounted on the frame 14 (see FIG. 6). A right power link 50 and a left power link 52 are each attached to the lower end of the respective one of the pedal sliders 36 and 38.

Seat 54 of the recumbent bicycle 10 is adjustably attached to frame 14 and to the top tube 18 and has an adjustable seat support rod 56. Only the frame of the seat 54 is shown to enable visualization of parts of the bicycle 10 below the seat 54, but it should be understood that the seat 54 has cushioned areas and other structure like a typical bicycle seat.

Although in a preferred embodiment of the invention, the seat 54 is configured to be in a substantially recumbent position, this position need not be completely horizontal in relation to the top tube 18, the pedals 44 and clutch system

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46. A rider positioned below or above the horizontal plane defined by the clutch system 46 may also work with the human-powered bicycle 10. In certain embodiments, it may be beneficial to raise the seat 54 above a plane defined by the clutch system 46 for better visibility of the bicycle operator.

It is beneficial if the power links 50, 52 run in a substantially horizontal plane at least in a portion 58 adjacent to the pedal sliders 36, 38. By being "substantially" horizontal, it is meant that this portion 58 should be parallel to the surface on which the bicycle 10 is placed for movement (an angle of 0 degrees therebetween), or within an angle of less than or equal to about 5 degrees to this surface. The horizontal, parallel positioning or specific angle is not critical to the invention but a preferred feature to maximize the benefits provided by the invention.

Namely, by configuring the power links 50, 52 in this manner, the transmission of force by the rider pushing the pedals 44 forward is maximized since there is no loss, or minimal loss, as a result of a vertical force component. Rather, pushing movement of the rider of the pedals 44 and the associated pedal sliders 36, 38 causes substantially the entire pushing force of the rider to be converted into a horizontally directed force that pulls the power links 50, 52 forward in the horizontal direction, causing them to move entirely in a horizontal plane (at least in that portion 58 adjacent to the pedal sliders 36, 38).

To cause the power links 50, 52 to be in the horizontal plane in the portion 58, a roller 60 is attached to the lower tube 20 at a certain height on each side of the lower tube 20. There is thus one roller 60 for the right power link 50 and one roller 60 for the left power link 52. The height of the rollers 60 is determined when manufacturing or assembling the bicycle 10 to be in the same horizontal plane as the lower end of the pedal sliders 36, 38 (or more specifically, that location at which the power links 50, 52 attach to the respective pedal sliders 36, 38). Rollers 60 should be considered optional structure.

In some embodiments, the pedal sliders 36, 38 may be adjustable to different heights to accommodate different riders. In this case, the rollers 60 are mounted on a displacement device 62 to enable them to slide up and down along the lower tube 20. The specific construction of the displacement device 62 can be a variety of different constructions. For example, the lower tube 20 may include apertures spaced apart from one another and the rollers 60 releasably connected to one another via a pin that extends through one of the apertures (the pin and apertures thus constituting the displacement device 62). The rider then releases one of the rollers 60 to expose the pin and places the pin through an aperture fitting their riding position and then reattaches the other roller 60, fixing the rollers 60 in place.

Other displacement structure may be a bracket placed along each side of the lower tube 20 and a complementary slider attached to each roller 60. The rider slides the roller 60 along the bracket to the desired riding position and then fixes the rollers 60 in place. Other constructions to provide for an adjustable or displaceable roller 60 are also contemplated to be within the scope of the invention. Generally, such structure is referred to as roller displacement means. These means enable movement of the roller 60 along the lower tube 20 in a preparatory stage while also fixing the rollers 60 in place in a use state.

Each roller 60 is structured to provide a channel or groove through which the respective power link 50, 52 passes (see FIGS. 8-11 of the '558 application). Ideally, the roller 60 should be designed to provide near frictionless passage of the power link 50, 52 over it. The depth of the channel or

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groove in the rollers **60** should be sufficient to prevent the power links **50, 52** from inadvertently falling out of the channel or groove. Rollers **60** may be considered like pulleys.

In the portion of the power link **50, 52** rearward of the rollers **60**, the power links **50, 52** have a linear path, but typically not in a horizontal plane. Rather, the power links **50, 52** are in a plane between the outlet location from the respective roller **60** and the inlet location to the respective clutch system **46**, which is often a plane oriented downward toward a rear of the bicycle **10**.

Accordingly, the bicycle **10** has a specific reason for the placement of a roller on a path of each of the power links **50, 52**, additional to causing a change in the plane in which the power links **50, 52** run. Specifically, the rollers **60** are positioned to cause a specific orientation of the plane in which the power links **50, 52** are situated forward of the rollers **60** to be substantially horizontal, with the forward end region of the power links **50, 52** in the portion **58** attaching to the pedal sliders **36, 38** and the rearward end region of the power links **50, 52** in the portion **58** running over the rollers **60**. As mentioned above, by substantially horizontal, it is meant that the deviation from the horizontal plane is no more than about 5 degrees. As such, rollers **60** are directional rollers which change the running direction or place of the power links **50, 52**. With this orientation (horizontal forward of the roller and angled rearward of the roller), the rider-caused forwarding movement of the pedals **44** is optimally converted into a maximal horizontal force pulling the power links **50, 52** forward. Additionally, the rider is better able to push the pedals **44** forward in the horizontal direction since there is no vertical force component dragging on the forwarding pushing movement of the pedals **44**.

Optionally, the lower end of the pedal sliders **36, 38** may be adjustable to improve the positioning of the portion **58** in a horizontal plane. To this end, each pedal slider **36, 38** may have a small roller, not shown, mounted in a track or bracket, also not shown, that is longitudinally extendible, i.e., extends up and down along the pedal slider **36, 38**. The track or bracket can be locked in position by a screw or other structure known to those skilled in the art. The user then can individually adjust the orientation of the portion **58** of the power link **50, 52** to be in a horizontal plane by adjusting one or both of the forward end of portion **58** retained on the pedal slider **36, 38** (via the movable track or bracket having the roller thereon) and the rearward end running over the roller **60** (via adjustment of the longitudinal position of the roller **60**). The bicycle **10** therefore includes adjustment means for adjusting the planar orientation of a portion **58** of the power link **50, 52** between the pedal slider **36, 38** and the respective roller **60** by adjusting the height of the power link **50, 52** at only one end or both ends of the portion **58** between the pedal slider **36, 38** and the respective roller **60**.

The bicycle **10** includes, as part of the clutch system **46**, a drum **140** on each side that is not cylindrical in shape, i.e., has a circular cross-section, but rather has an eccentric shape. The drum **140** is part of the clutch and transmission mechanism on each side of the bicycle **10**.

The drum **140** includes a circular portion **142** and a fin **144** extending radially outward from the circular portion **142** on one side thereof (over an arcuate region thereof), preferably the side on which the respective power link **50, 52** will first contact the respective drum **140** when the bicycle **10** is at an at rest state. This side is typically the top side of the circular portion **142** since each power link **50, 52** will have its straight, free running portion to the respective pedal

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slider **36, 38** above the respective drum **140** (best seen in FIG. 5). Each fin **144** has opposite planar sides which may be contiguous with the planar sides of the circular portion **142**. Additional details of the clutch system are described below with reference to FIGS. 5 and 6.

FIG. 2 is a perspective view of part of the linear drive mechanism **12** in which a vinyl-coated metal cord is used for each of the power links **50, 52**. Each power link **50, 52** is attached to the respective pedal slider **36, 38** by a clamp **64** at a height along the pedal slider **36, 38**. For the ease of description, an explanation of the manner in which one of the power links **50, 52**, power link **52**, is attached to the pedal slider **38** will be explained, but the other power link **50** is attached to the pedal slider **36** in the same manner.

The end **66** of the power link **52** is clamped by clamp **64** at a location between the bottom end region and the upper end region of the pedal slider **38**. The exact height depends on the manner in which the rider wants to use the bicycle, explained below, since there is a difference in the conversion of force into movement relative to the attachment point of the power link **52** to the pedal slider **38**.

Structure is provided on the pedal slider **38** to retain the power link **52** in connection therewith below the location at which it is clamped to the pedal slider **38** by the clamp **64**. This structure may include, for example, a loop or hook **68** arranged at the lower end of the pedal slider **38** and through which the power link **52** passes, and/or a bracket **70** along the pedal slider **38** with a groove into which the power link **52** is placed. The objective of this structure is to ensure that the clamp **64** retains the power link **52** in connection with the pedal slider **38** and also cause the power link **52** to separate from the pedal slider **38** at its lower end and allow the power link **52** to be oriented in a horizontal plane between the lower end of the pedal slider **38** and the roller **60**.

By securing a portion of the power links **50, 52** to the respective pedal slider **36, 38**, a more secure attachment of the power links **50, 52** to the pedal sliders **36, 38** is achieved. This reduces potential breakage of the drive mechanism **12** of the bicycle **10** during use.

FIG. 3 is a perspective view of part of the linear drive mechanism **12** in which a metal chain is used for each of the power links **50, 52**. In other respects, the embodiment of FIG. 3 is the same as the embodiment of FIG. 2.

FIG. 4 is a perspective view of part of the linear drive mechanism **12** in which a belt is used for each of the power links **50, 52**. In other respects, the embodiment of FIG. 4 is the same as the embodiment of FIG. 2. The belt may be like a car timing belt or another type of belt.

Although the power links **50, 52** are described as being a metal cord, metal chain or belt, FIGS. 2, 3 and 4, respectively, they may be other equivalent or comparable structures that can transfer force along their length. It is also possible to use different type of power links **50, 52** on the same bicycle **10**. Thus, while the present invention provides three specific examples of flexible power links, i.e., vinyl-coated metal cords, metal chains and belts, the flexible power links **50, 52** may also be made out of any number of materials suitable to the typical stresses experienced with the use of the linear drive mechanism **12** of the present invention.

FIGS. 5, 6 and 7 of the '558 application and the description thereof provide an explanation of the effect of the attachment of the power links **50, 52** to the pedal sliders **36, 38**, respectively, at different heights, and use of a specific type of clamping structure, all of which are relevant to the invention and incorporated by reference herein.

Referring back to FIG. 5, the double stroke linear drive mechanism 12 includes the clutch system 46 and the flexible power links 50 and 52. Clutch system 46 includes two overrunning clutches 84 mounted to a common transmission axle 90, the general design of overrunning clutches being known to those skilled in the transmission field. In the illustrated embodiment, each overrunning clutch has outer and inner rings 86 and 88. Rings 86, 88 are alternatively considered or termed races or gears, or other comparable terminology used by those in the transmission field. The drum 140 is connected to a respective outer ring 86. The power links 50, 52 are each connected to a respective drum 140. Outer and inner rings 86, 88 are configured such that when outer ring 86 rotates in one direction, the inner ring 88 is engaged with the outer ring 86 and rotates as well in the same direction. However, when outer ring 86 rotates in the opposite direction, the inner ring 88 is disengaged with the outer ring 86 and does not rotate. The direction of rotation of the outer ring 86 varies depending on the side of the bicycle 10. The outer and inner rings 86, 88 on the left side of the bicycle 10 are engaged when the outer ring 86 rotates counterclockwise (when viewed from the left side of the bicycle 10) and outer and inner rings 86, 88 on the right side of the bicycle 10 are engaged when the outer ring 86 rotates clockwise (when viewed from the right side of the bicycle 10).

Rotation of the inner ring 88 is transmitted to the rear wheel 16 via the main drive sprocket plate 26 which is fixed to the transmission axle 90 to which the inner ring 88 is fixed, and a drive chain 28 that passes around the outer periphery of the main drive sprocket plate 26.

Rotation of the outer ring 86 is caused by pulling of the power link 50, 52, which causes the respective drum 140 to rotate and thus the outer ring 86 to rotate in view of its fixing to the drum (see FIG. 6).

Biasing members, such as spiral torsional springs 92, are provided to cause the reverse rotation of the outer ring 86.

Additional features of the drive mechanism 12 includes a transmission main chain axis drive 94 having the transmission axle 90 located in the transmission bracket 48 and bearings 96 between an inner surface of the transmission bracket 48 and an outer surface of the transmission axle 90 to enable rotation of transmission axle 90 relative to the transmission bracket 48. Overrunning clutches 84 are thus installed on the elongate transmission axle 90, allowing drums 140 to freely rotate when no pedaling occurs. Overrunning clutches 84 engage the transmission when pedaling occurs to induce rotation of the main drive sprocket plate 26, which is rigidly connected to the transmission axle 90. The main drive sprocket plate 26 acts like a standard forward sprocket wheel on a standard bicycle.

To return drums 140 to a working position, flexible power links 50, 52 perform idle motion on a return stroke cycle 100 (see FIGS. 2, 3 and 4), as the spiral torsion return spring 92 rotates the outer ring 86 of the overrunning clutch 84 (connected to drum 140) in the opposite direction. Then, the outer ring 86 performs a power stroke cycle 102 (see FIGS. 2 and 3) when drum 140 rotates the overrunning clutch outer ring 86 engaged with the inner ring 88 of the overrunning clutch 84 and transmits the rotation to transmission axle 90, the main drive sprocket plate 26 and the main drive chain 28. At the same time, the overrunning clutch inner ring 88 compresses the spiral torsion return spring 92. This sequence repeats itself as the rider moves the pedals forward and backward, power stroke, return stroke, power stroke, return stroke, etc.

As known to those skilled in the art, as the outer ring 86 rotates, the main drive sprocket plate 26 rotates causing the main drive chain 28 that is threaded over it to move and the rear wheel drive sprocket 30, over which the main drive chain 28 is also threaded, to rotate thereby causing rotation of the rear wheel 16 to which the rear wheel drive sprocket 30 is connected (see FIG. 1). Thus, in the power or motive stroke, the outer ring 86 is in engagement with the inner ring 88, while in the return stroke, the outer ring 86 is not in engagement with the inner ring 88. Also, FIG. 6 clearly shows that there are two clutch systems 46 of the drive mechanism 12, one on each side of the frame 14.

The clutch 84 of the clutch system 46 on each side of the frame 14 is shown. The drum 140 of each clutch 84 has an opening in which at least a part of the outer ring 86 and at least a part of the inner ring 88 are situated. The inner ring 88 is housed in a cavity in the outer ring 86. The outer ring 86 extends inward toward the frame 14 while the inner ring 88 is mostly housed in a space defined by the outer ring 86. The single main drive sprocket plate 26 is between the transmission bracket 48 that is fixed to the frame 14, and the inner ring 88 on one side of the transmission bracket 48.

The left and right power stroke/return cycles 100, 102 are independent from one another. Because of this independent action, the rider can use both legs simultaneously when necessary to provide more power to the bicycle 10, such as, for example, when accelerating, riding uphill or carrying larger loads (e.g., passengers in a rickshaw-like configuration). Likewise, the rider may alternate between left and right leg motion such as used in a typical upright or recumbent bicycle. Finally, the bicycle 10 may be propelled with the use of either the right or left leg in a single-stroke action.

Each power link 50, 52 interacts with the respective drum 140 in a manner to improve the transmission of force from the power link 50, 52 to the drum 140, and in turn to the transmission axle 90.

Referring back to FIG. 5, the fin 144 has an outer power link-engaging edge 146 that aligns with the outer power link-engaging edge 148 of the circular portion 142 to provide a contiguous path for the power link 50. The power link-engaging edge 146 is typically contoured or profiled to engage with or mate with the power link 50, e.g., provided with grooves or channels to receive the bars in the links of the power link 50 as known to those skilled in the art to which this invention pertains.

The power link 50 can coil around the drum 140 in the same manner as it is shown coiling around the drums in FIGS. 5-11 of the '558 application. If the length of the power link 50 that wraps around the drum 140 is greater than the size of the outer power-link engaging surfaces or edges of the fin 144 and circular portion 142 combined, the fin 144 can be provided with a channel through which the power link 50 passes in the circular portion thereof, instead of being solid between its opposing planar surfaces, as shown in FIG. 6 (this optional channel being designated 156 and shown in dotted lines in FIG. 5). Thus the fin 144 would include a hollow channel between its opposing planar surfaces dimensioned to allow for passage of the power link 50 therethrough.

Outer power link-engaging edge 146 is arcuate and serves to increase a distance between the center of the drum 140 and the point at which the power link 50 separates therefrom. After the power link 50 separates from the drum 140 (at point SP), there is optionally a short outer edge portion 150 of the fin 144 extending to a forwardmost edge 152 of the fin 144 and an underlying edge portion 154 that connects

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the forwardmost edge **152** of the fin **144** to the circular portion **142** of the main drive sprocket plate **140**. The fin **144** thus points toward the pedal **44**.

An important advantage of this embodiment using fin **144** is that by increasing a distance between the center of the drum **140** and the point at which the power link **50** separates therefrom, the moment of force (force times distance) is increased in comparison to a situation where the power link **50** separates from a cylindrical drum. This increase in distance leads to a corresponding increase in the moment of force and therefore a relatively larger force is effective to rotate the drum **140** when the power link **50** is moved forward (in the illustrated embodiment of FIG. 5).

Instead of the fin **144**, any other comparable or equivalent structure that serves to increase the distance between the center of the drum **140** and the point at which the power link **50** separates from the outer power link-engaging edge of the drum **140** may be used in the invention. The larger this distance, the larger the effective force applied to rotate the drum **140**, again in comparison to a situation where the drum is cylindrical and the separation point of the power link **50** from the outer power-link engaging edge of the cylindrical drum is closed to the center of the cylindrical drum. Any such structure known to those skilled in the art or obtainable/derivable by those skilled in the art in view of the disclosure herein will be considered to be encompassed by means for increasing a distance between a center of the drum and an outer power-link engaging surface of the drum, while the power link **50**, **52** passes over the means and has a free portion between the means and the associated pedal slider **36**, **38**.

This eccentrically shaped drum **140** with its distinctive fin **144** may be used in any of the embodiments disclosed herein instead of the cylindrical drum (or drum with a circular cross-section) to obtain the advantage described above. In each case, the power link **50**, **52** would pass over a fin **144** so that the distance between the point SP at which the power link **50**, **52** separates from the drum **140** and the central or rotational axis of the drum, is increased relative to a situation where there is no fin.

The torsion and linear springs used in this invention may be made of any suitable material allowing for a spring-like action, such as, for example, metal, rubber or plastic. Likewise, the bicycle of the present invention may be constructed out of typical materials used for bicycles, tricycles and other human-powered vehicles, including metal, plastic, rubber, fiberglass, and wood and wood composite materials. The inventive vehicle is not limited to a bicycle as shown but may be any vehicle having one or more wheels, including unicycles, tricycles, quadricycles or party bikes, and the like. One or more wheels may be coupled to the drive mechanism, and one or more other wheels may be coupled to the steering mechanism. Thus, the invention should be considered a vehicle, without limitation to the illustrated embodiment of bicycles.

An important aspect of the invention is that when the rider sits, the rider pushes their feet outward and backward in a linear manner to propel the vehicle **10**. The rider does not perform a cyclical motion with their feet or hands. In this regard, it is possible to configure the vehicle to be hand-actuated, and the claimed embodiment is not limited to foot-actuation.

Although certain figures shown herein describe a bicycle, the linear drive mechanism connected by a flexible power link to a double overrunning clutch transmission with returning springs may be utilized on various recumbent human-

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powered vehicles such as tricycles, four-wheeled vehicles for carrying larger loads and passengers and other multi-wheel variants.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

The invention claimed is:

1. A transmission system for a manually powered vehicle having a rotatable drive sprocket coupled to a wheel, comprising:

a pedal;

an overrunning clutch system comprising a drum;

a power link coupled at a first end region to said pedal and at a second, opposite end region to said drum, said drum having a circular portion and a fin extending radially outward from said circular portion, said power link passing over said fin and at least a part of said circular portion and having a free portion between said fin and said pedal, movement of said pedal in a first direction causing movement of said power link and rotation of said drum in a second direction; and

a transmission member coupled to said overrunning clutch system and to the rotatable drive sprocket, rotation of said drum in the second direction causing movement of said transmission member and rotation of the rotatable drive sprocket,

said overrunning clutch system being configured such that rotation of said drum in a direction opposite to the second direction does not cause movement of said transmission member and rotation of the rotatable drive sprocket.

2. The system of claim 1, wherein said fin is above said circular portion and said power link has a free portion between said pedal and a separation point at which it separates from contact with said fin and which free portion is above said drum.

3. The system of claim 1, wherein said fin has an outer power link-engaging edge that aligns with an outer power link-engaging edge of said circular portion to provide a contiguous path for said power link over said drum.

4. The system of claim 3, wherein said outer power link-engaging edge of said fin is arcuate.

5. The system of claim 1, further comprising a pedal slider to which said pedal is attached, said power link running alongside said pedal slider above said pedal.

6. The system of claim 5, further comprising a clamp to attach said power link to said pedal slider, said clamp being configured to attach said power link to said pedal slider at a plurality of different heights relative to a bottom region of said pedal slider.

7. The system of claim 5, wherein said power link is attachable to said pedal slider at a plurality of different heights relative to a bottom region of said pedal slider.

8. The system of claim 5, further comprising a fixator that fixes said power link to said pedal slider at one of a plurality of possible different heights relative to a bottom region of said pedal slider.

9. The system of claim 1, wherein said overrunning clutch system further comprises an outer ring and an inner ring configured such that rotation of said outer ring in a third direction causes rotation of said inner ring while rotation of said outer ring in a direction opposite to the third direction does not cause rotation of said inner ring, said inner ring

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being motively coupled to the rotatable drive sprocket via said transmission member such that rotation of said inner ring causes rotation of the rotatable drive sprocket and results in rotation of the wheel.

10. The system of claim 9, wherein said overrunning clutch system further comprises a transmission axle to which said inner ring is fixed, the rotatable drive sprocket being fixed to said transmission axle, said transmission member passing around an outer periphery of the rotatable drive sprocket.

11. The system of claim 10, wherein overrunning clutch system further comprises at least one biasing member that biases said outer ring to rotate in the direction opposite to the third direction, said at least one biasing member being arranged in connection with said transmission axle.

12. A vehicle, comprising:

the system of claim 1;

a frame movably supporting said pedal and supporting said overrunning clutch system;

at least two wheels that support said frame on a horizontal surface, one of said wheels having the rotatable drive sprocket; and

a seat for receiving a person to use the vehicle, said seat being situated relative to said pedal to enable the person when in said seat to engage with said pedal.

13. A manually powered vehicle, comprising:

a frame;

at least first and second wheels rotatably coupled to said frame and that support said frame on a horizontal surface;

a rotatable drive sprocket connected to said first wheel;

a first transmission system supported by said frame and comprising:

a first pedal;

an overrunning clutch system comprising a first drum;

a first power link coupled at a first end region to said first pedal and at a second, opposite end region to said first drum, said first drum having a circular portion and a fin extending radially outward from said circular portion, said first power link passing over said fin and at least a part of said circular portion and having a free portion between said fin and said first pedal, movement of said first pedal in a first direction causing movement of said first power link and rotation of said first drum in a second direction;

a transmission member coupled to said overrunning clutch system and to said rotatable drive sprocket, rotation of said first drum in the second direction causing movement of said transmission member and rotation of said rotatable drive sprocket, said overrunning clutch system being configured such that rotation of said first drum in a direction opposite to the second direction does not cause movement of said transmission member and rotation of said rotatable drive sprocket; and

a seat for receiving a person to use the vehicle, said seat being situated relative to said first pedal to enable the person when in said seat to engage with said first pedal.

14. The vehicle of claim 13, wherein said fin is above said circular portion and said first power link has a free portion

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between said first pedal and a separation point at which it separates from contact with said fin and which free portion is above said first drum.

15. The vehicle of claim 13, wherein said fin has an outer power link-engaging edge that aligns with an outer power link-engaging edge of said circular portion to provide a contiguous path for said first power link over said first drum.

16. The vehicle of claim 13, further comprising a first pedal slider to which said first pedal is attached, said first power link running alongside said first pedal slider above said first pedal.

17. The vehicle of claim 13, wherein said overrunning clutch system further comprises an outer ring and an inner ring configured such that rotation of said outer ring in a third direction causes rotation of said inner ring while rotation of said outer ring in a direction opposite to the third direction does not cause rotation of said inner ring, said inner ring being motively coupled to said rotatable drive sprocket via said transmission member such that rotation of said inner ring causes rotation of said rotatable drive sprocket and results in rotation of said first wheel.

18. The vehicle of claim 17, wherein said overrunning clutch system further comprises a transmission axle to which said inner ring is fixed, said rotatable drive sprocket being fixed to said transmission axle, said transmission member passing around an outer periphery of said rotatable drive sprocket.

19. The vehicle of claim 18, wherein overrunning clutch system further comprises at least one biasing member that biases said outer ring to rotate in the direction opposite to the third direction, said at least one biasing member being arranged in connection with said transmission axle.

20. The vehicle of claim 13, wherein said overrunning clutch system comprises a second drum, the vehicle further comprising:

a second transmission system supported by said frame and comprising:

a second pedal on an opposite side of said frame from said first pedal;

a second power link coupled at a first end region to said second pedal and at a second, opposite end region to said second drum, said second drum having a circular portion and a fin extending radially outward from said circular portion of said second drum, said second power link passing over said fin of said second drum and at least a part of said circular portion of said second drum and having a free portion between said fin of said second drum and said second pedal, movement of said second pedal in the first direction causing movement of said second power link and rotation of said second drum in the second direction, rotation of said second drum in the second direction causing movement of said transmission member and rotation of said rotatable drive sprocket, said overrunning clutch system being configured such that rotation of said second drum in the direction opposite to the second direction does not cause movement of said transmission member and rotation of said rotatable drive sprocket,

said second pedal being situated relative to said seat to enable the person when in said seat to engage with said second pedal.

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