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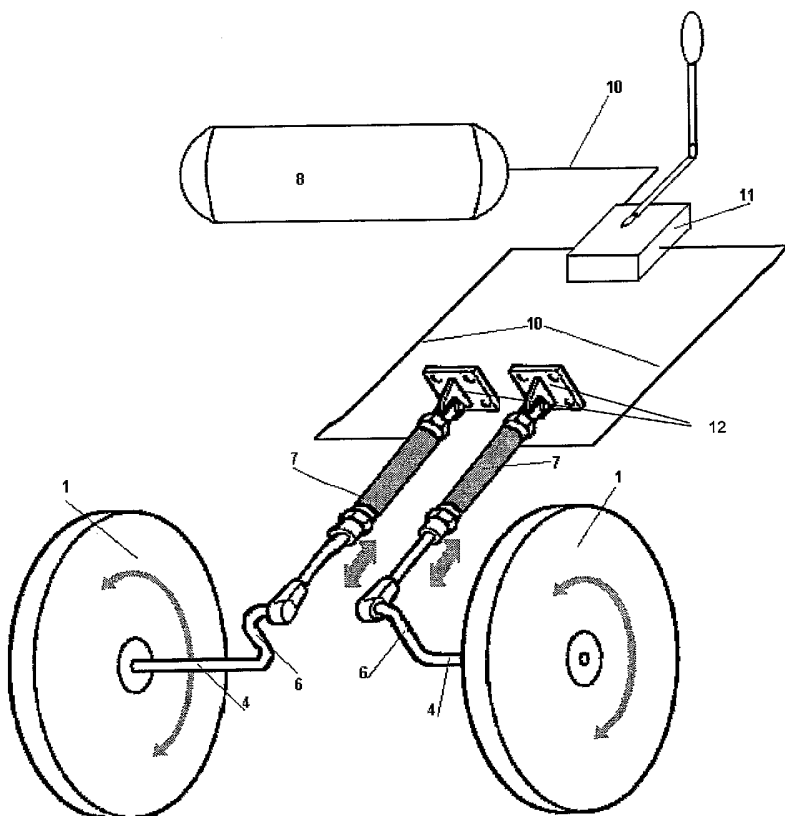
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(54) Title: POWERED PERSONAL LIGHT VEHICLE WITH PNEUMATIC PROPULSION SYSTEM



(57) Abstract: Personal pneumatically-powered or power-assisted light wheeled and tracked vehicles are provided. In some embodiments, the vehicle includes drive wheels propelled by a reciprocating pneumatic prime mover fastened to the structure of the vehicle. In some embodiments, every drive wheel is propelled by a different single pneumatic prime mover operative to turn the driving wheel through a crank arm, one-way clutch or any other arrangement, converting the prime mover reciprocating motion to rotation motion, directly or indirectly through a supplementary drive device or/and transaxle comprising steering device. The disclosed vehicle includes a control mechanism for controlling the velocity or the velocity and direction of the vehicle. In some embodiments, the disclosed vehicle is a skid steer vehicle, and steering is provided by controlling the relative rotational velocity of drive wheels. Exemplary reciprocating prime movers include but are not limited to pneumatic cylinders, rotary actuators, fluidic muscles, and pneumatic bellows.



For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

POWERED PERSONAL LIGHT VEHICLE WITH A PNEUMATIC PROPULSION SYSTEM

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to powered personal light vehicles, and in particular to a pneumatically powered propulsion system for personal light vehicles such as, but not limited to, wheelchairs, scooters, golf carts, and cycles.

Electrically powered personal light vehicles such as wheelchairs, scooters and others are well known in the art. Generally, each of these powered or power-assisted light vehicles are equipped with an electric drive system including a power management and monitoring system, one or more electric motors and a transmission.

Most power management and monitoring systems include a battery, a recharging device, and a monitoring device or gauge for indicating remaining battery capacity. Power light vehicles are presently powered by deep discharge lead-acid (mostly gel-cell) batteries, with 24 volts the most common configuration. Virtually every commercial wheelchair uses lead-acid batteries, as they have been the most reliable, cost effective and practical battery on the market for decades. Typical battery life is 9-14 months or 365 cycles annually.

Unfortunately, lead batteries tend to be heavy, making battery replacement difficult for the user and limiting portability of spare batteries. Lead batteries also tend to be bulky, impacting wheelchair design due to the space required under the seat. Furthermore, the limited current output provided by lead batteries degrades performance in high torque situations.

Battery power indicators such as simple voltmeters for displaying the state of charge are of vital importance in battery powered personal light vehicles. These simple voltmeters are commonly used because they are inexpensive and compact devices. Unfortunately, given the power discharge curve for lead acid batteries, readings from a voltmeter monitors are at best inaccurate, and at worst misleading.

Typically, the propulsion system of electrically powered wheelchairs consists of a pair of electric motors, one for each drive wheel, and a drive train consisting of gears, belts and other mechanical elements that couples the motor's shaft to the drive wheel shaft. Sometimes the electric motors are directly coupled to the drive wheels. The main problem with electric drive vehicles is their inability to generate a high startup torque and high torque

for negotiating inclines such as ramps and curbs, and difficult surfaces such as gravel, soft soil, and sand.

Another approach is to construct a light vehicle that uses a fluid-power motor rather than an electric motor as a prime mover. Fluid-powered motors that convert energy from compressed air or compressed gas into mechanical motion are well known in the art, and have been employed for years in industrial devices such as pneumatic drills, screwdrivers, and the like. These motors are usually classified according to the type of internal element, which is directly actuated by the flow. The most common types of elements are gears, vanes, and pistons such as radial-piston and axial-piston compressed air motors.

There are several disclosures related to pneumatic-powered motor vehicles. The French company Moteur Developpement International (MDI) has developed an automobile powered by compressed air. The prime mover of the automobile is an in-line four-cylinder pneumatic motor, in which air expands to push pistons that in turn drive a crankshaft, in a manner similar to that of an internal combustion engine. These systems are of limited relevance to personal light vehicles due to the motor's size, high weight and cost.

Angelo Di Pietro of Engineair Motors, Australia has developed a pneumatically powered garden buggy. Nevertheless, the disclosed garden buggy, which is equipped with conventional upgraded pneumatic motors, is also of limited relevance to personal light vehicles due to the disadvantages mentioned above.

At the same time, there is a well-known family of reciprocating pneumatic devices including: linear double-acting cylinders (pushing and pulling power strokes); linear single-acting cylinders (pushing or pulling power strokes); pneumatic double or single-acting rotary actuators (back-and-forth rotation between two positions); pneumatic rubber bellows that can push only; and fluidic muscles that can pull only.

In addition, it is known that any reciprocating mechanism generally can be combined with any special arrangement to convert reciprocating motion to rotation using a crank arm, one-way clutch, or other such device. A combination of a reciprocating prime mover and substantially any converting device provides a rotating power source. A steam locomotive power train serves as good example.

The German firm Festo has disclosed both two wheeler and three-wheeler functional prototypes, in which reciprocating pneumatic muscle movement is converted in drive axle rotation. In the first case, the crankshaft is connected to one driving wheel, in the second case

the crankshaft drives a common axle connected to the left and right wheels. Vehicle turning is effected by the use of a steerable front wheel.

However, due to the range of the fluidic muscle disadvantages such as, the stroke range of the fluidic muscle being typically 20-25% of its physical length, the muscle is able to operate as a single-acting pulling actuator only, and rated force is changed throughout the muscle stroke. The above arrangement is complex, cumbersome and is configured as a three or six cylinder two-stroke in-line powerplant where the pistons and cylinders have been replaced by three or six fluid muscles driving a crankshaft.

The complications associated with the disclosed Festo prototypes make this device of limited relevance to big groups of light vehicles, especially two wheelers and vehicles with skid-steering locomotion. On these vehicles the wheels or tracks on each side are driven at differential speeds in forward and reverse, causing the wheels or tracks to slip or skid on the ground. In this case there would be difficulties with deploying the devices onto each side of the wheelchair, providing a change of the wheel rotation direction.

Thus, there is an apparent need for relatively lightweight, reliable and inexpensive pneumatic drive systems for powered and power-assisted light personal vehicles including but not limited to vehicles intended for the disabled such as wheelchairs and scooters.

SUMMARY OF THE INVENTION

The present invention is pneumatically powered propulsion system for personal light vehicles.

According to the teachings of the present invention there is provided, a pneumatically powered light personal vehicle comprising: (a) at least two drive wheels, wherein each of said drive wheels is actuated by a sole pneumatic reciprocating actuator, and each of said sole pneumatic reciprocating actuators is mechanically linked to the corresponding one of said at least two drive wheels; and (b) at least one gas storage reservoir for supplying pressurized gas to each of said reciprocating actuators.

According to a further teaching of the present invention, said reciprocating actuators are single-acting actuators.

According to a further teaching of the present invention, said pneumatic reciprocating actuator is mechanically linked to the corresponding drive wheel by a one-way clutch.

According to a further teaching of the present invention, said one-way clutch is associated with a supplementary transmission mechanism.

According to a further teaching of the present invention, said reciprocating actuators are double-acting.

According to a further teaching of the present invention, said pneumatic reciprocating actuator is mechanically linked to the corresponding one of said drive wheels by a crank arrangement.

According to a further teaching of the present invention, said crank arrangement is associated with a supplementary transmission mechanism.

According to a further teaching of the present invention, there is also provided a control mechanism for controlling rotational speed of said drive wheels.

According to a further teaching of the present invention, said control mechanism includes a valve configured to direct flow of said pressurized gas to a double-acting reciprocating actuator so as to effect power strokes in both directions of reciprocating motion of said double-acting reciprocating actuator, synchronization of said valve with rotation of said drive wheel being effected by a cam mechanism mechanically linked to said drive wheel.

According to a further teaching of the present invention, said control mechanism controls the direction of rotation of at least one of said drive wheels.

According to a further teaching of the present invention, said control mechanism is configured to vary a flow rate of said pressurized gas to one, the other, or both of said pneumatic reciprocating actuators.

According to a further teaching of the present invention, rotation of said at least two drive wheels is effected solely by mechanical components.

According to a further teaching of the present invention, said gas storage reservoir is configured for use with compressed gases.

According to a further teaching of the present invention, said gas storage reservoir is configured for use with liquefied gases.

There is also provided according to the teachings of the present invention, a pneumatically powered light personal vehicle comprising at least one drive wheel, wherein each said at least one drive wheel is actuated by a sole double-acting reciprocating actuator.

According to a further teaching of the present invention, there is also provided a control mechanism for controlling rotational speed of said drive wheel.

According to a further teaching of the present invention, said reciprocating actuator is mechanically linked to said at least one drive wheel by a crank arrangement.

According to a further teaching of the present invention, said crank arrangement is associated with a supplementary transmission mechanism.

There is also provided according to the teachings of the present invention, a pneumatically powered light personal vehicle comprising: (a) at least two drive wheels; (b) a selective power distribution mechanism for distributing power to one, the other, or both of said drive wheels; (c) at least one pneumatic actuator configured to supply power to said selective distribution mechanism; and (d) at least one gas storage reservoir for supplying pressurized gas to each said reciprocating actuator; wherein steering of the light personal vehicle is effected by varying distribution of power to said drive wheels.

According to a further teaching of the present invention, said at least one pneumatic actuator is a single-acting pneumatic actuator.

According to a further teaching of the present invention, said at least one pneumatic actuator is a double-acting pneumatic actuator.

According to a further teaching of the present invention, said selective distribution mechanism is configured to vary a rotational speed of one, the other, or both of said drive wheels.

According to a further teaching of the present invention, said selective distribution mechanism is a braked differential.

According to a further teaching of the present invention, said gas storage reservoir is configured for use with compressed gases.

According to a further teaching of the present invention, said gas storage reservoir is configured for use with liquefied gases.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a schematic isometric view of a general propulsion system for a personal light vehicle according to some embodiments of the present invention, equipped with a single pneumatic double-acting linear prime mover for each wheel;

FIG. 2 is a schematic view of a powered wheelchair, constructed according to some embodiments of the present invention, that includes two pneumatic cylinders having reciprocating pistons and rods, each connected to a separate drive wheel by crankshaft arms;

FIG. 3 is a schematic view of a powered wheelchair, constructed according to some embodiments of the present invention, that includes two fluidic muscles, each connected to a separate drive wheel by one-way clutches;

FIG. 4 is a schematic of a propulsion mechanism and control means of the vehicle constructed according to some embodiments of the present invention, with single double-acting pneumatic cylinders as prime movers;

FIG. 5 is a kinematics' schematic of a propulsion system comprising only one linear double-acting prime mover and braked differential steering; and

FIG. 6 is schematic view of the wheelchair equipped with the propulsion system of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a pneumatically powered propulsion system for personal light vehicles.

The principles and operation of a pneumatically powered propulsion system for personal light vehicles according to the present invention may be better understood with reference to the drawings and the accompanying description.

By way of introduction, the aforementioned needs are satisfied by several features of the present invention.

According to some features, the present invention provides a pneumatic system for propelling a wheeled or tracked light vehicle, employing a single reciprocating double-acting prime mover operatively coupled to a crank arm, bi-directional ratchet-clutch, or substantially any other arrangement for converting the prime mover power two-stroke reciprocating motion into rotational movement, that are joined to one or more drive wheels. That is, one preferred embodiment of the present invention includes at least two drive wheels and separate sole reciprocating actuators dedicated to actuate the drive wheel with which it is associated. Preferably, the reciprocating actuators are mechanically linked to the axle of its respective drive wheel.

It is now disclosed for the first time a vehicle with one or more powered drive wheels having a single reciprocating pneumatic actuator operatively coupled to each driving wheel or a steering transaxle comprising the steering device.

The disclosed vehicle is pneumatically powered, and includes a pneumatic prime mover such as, but not limited to, a single pneumatic reciprocating double-acting prime

mover. Appropriate pneumatic prime movers include, but are not limited to, pneumatic double-acting linear actuators (cylinders) and rotary pneumatic actuators. As used herein, the phrase "double-acting actuator" is used in reference to reciprocating actuators that provide a power stroke in each of the reciprocating directions. The term "reciprocating" as used herein refers to a repetitive movement sequentially traversing a single path in two directions.

In the case where the prime mover is a single-acting pneumatic actuator such as, but not limited to, pneumatic cylinders, rotary actuators, pneumatic bellows, and fluidic muscles, the actuator may be combined with one-way clutch, crank arm or other similar device, that is engaged automatically to displace the drive wheel in the appropriate direction within a one-half wheel revolution. As used herein, the phrase "single-acting actuator" is used in reference to reciprocating actuators that provide a power stroke in only one of the reciprocating directions. The term "one-way clutch" as used herein, refers to the general class of clutches that provide power in only one direction of rotation, such as a ratchet-clutch for example.

According to some embodiments, the vehicles of the present invention includes one or more gas storage reservoirs filled with any compressed gas and/or any liquefied gas to serve as an energy source and to supply the pneumatic prime movers with pressurized gas. Exemplary compressed gases include, but are not limited to, air and nitrogen. Exemplary liquefied gases include, but are not limited to, air, nitrogen, and carbon dioxide. It should be noted that the phrases "storage reservoir" and storage tank" are used interchangeably herein to refer to substantially any container suitable for the storage of compressed or liquefied gas. The phrase "pressurized gas" is used herein with regard to gas that is under pressure, regardless of its storage stated as a liquefied or compressed gas.

According to some embodiments, the presently disclosed vehicle is equipped with control mechanism such as, but not limited to, a valve or valves for controlling the flow rate of pressurized gas to one or more of the pneumatic prime movers. In various embodiments, the control mechanism enables control of the speed only, or speed and direction, of individual drive wheel rotation and enables synchronizing of the prime mover strokes and the crank arm angle position within its one revolution. When coupled with a double-acting actuator, the control mechanism may include a valve configured to direct flow of the pressurized gas so as to deliver pressurized gas to each of the chambers of the actuator thereby effecting power strokes in both directions of the reciprocating motion of the actuator. Synchronization of the valve with rotation of said drive wheel is effected by a cam mechanism mechanically linked to said drive wheel as will be discussed below.

It should be noted that the propulsion system of the present invention may be implemented as a completely mechanical system. That is to say, it is possible to implement the propulsion system of the present invention without the use of electronic devices or components.

According to some embodiments, reciprocal motion of one prime mover is translated into unidirectional or bi-directional rotation of one or two drive wheels by one or more pneumatic actuators associated with drive wheels. The pneumatic actuators may be connected to the drive wheels directly by, for example but not limited to, crank arms, one-way clutches or substantially any other mechanism converting reciprocating motion to rotation motion. Alternatively, the pneumatic actuators may be connected to the drive wheels by supplementary transmission mechanisms such as, but not limited to, belts, chains, axles, semi-axles, clutches, differentials, or a planetary drive. It should also be noted that when the drive mechanisms are employed the ratio of actuator stroke to drive wheel rotation need not be 1:1. That is, the drive mechanism may also implement a change in "gearing" or change in the ratio of actuator stroke to drive wheel rotation.

According to some embodiments, each pneumatic prime mover may be pivotally fastened to the vehicle structure at one end, and at the other end to a crank arm or other mechanism for converting the linear reciprocating drive motion of the pneumatic actuator to rotational motion of the drive wheel, or drive wheel axle associated with the drive wheel.

According to some embodiments, the present invention provides a vehicle with skid-steering locomotion, such as a wheelchair for the disabled, small tracked vehicle for children, etc. In one particular embodiment, the vehicle is provided with first and second ground-engaging drive wheels or tracks respectively disposed on opposite sides of the vehicle, and each drive wheel or track is independently driven by the corresponding single pneumatic reciprocating prime mover to which it is coupled.

In another particular embodiment the vehicle is provided with first and second ground-engaging propulsion wheels or tracks respectively disposed on opposite sides of the vehicle, and each propulsion wheel or track is driven by a common single prime mover through any steering device, which engages, disengages or/and brakes the corresponding wheel. That is, one single reciprocating prime mover drives a common steering transaxle, which in turn drives the wheels simultaneously while moving straight and alternatively disengages or/and brakes one or the other driving wheels while turning. Exemplary steering devices include, but are not limited to, braked differential, side clutches and planetary

mechanisms. That is to say, power is distributed to one, the other or both of at least two drive wheels through a selective power distribution mechanism that is configured to vary the speed of one, the other or both of the drive wheels.

According to alternate embodiments, the present invention provides wheeled vehicles with separate steerable wheels, including but not limited to, bicycles, other two-wheeled cycles, two- and three-wheeled scooters, and four-wheeled light vehicles. The alignment of steered wheels may be altered directly or indirectly in relation to the alignment of the vehicle in order to obtain a change in the direction of forward or reverse motion of the vehicle.

It is now disclosed for the first time a control and drive system for a pneumatically powered skid-steering vehicle. According to some embodiments, the control and drive system allows for independent control of the speed and direction of left and right wheels. Thus, if the wheels on both sides of the vehicle are rotated in the same direction at different rates of rotation, or if one wheel is not rotated, the result is that the vehicle turns about the slow wheel. When the drive wheels on opposite sides of the vehicle are rotated in opposite directions, the result is a zero radius turn about a central vertical axis between driving wheels.

According to some embodiments, control levers are provided to drive and steer the vehicle. Upon shifting of a control lever by the vehicle occupant, a prime mover applies force to the crank arm so as to provide forward or reverse rotation to one or more of the driving wheels.

Not wishing to be bound by theory, it is noted that the presently disclosed control and drive systems for a pneumatically powered vehicle are simple, inexpensive, and serviceable, benefiting from high reliability and operability without the need for frequent or complicated repair.

The use of a pneumatic drive instead of electric motors offers a number of advantages. First of all, pneumatic motors tend to be more compact and to have a high power to weight ratio.

Furthermore, it is noted that the output speed and torque of pneumatic engines can be controlled simply by regulating either the flow rate, the pressure or both, of the pressurized gas, obviating the need for expensive control equipment.

In addition, if a pneumatic actuator is maintained in a near stalled condition for a length of time, substantially no damage is caused to the actuator.

According to some embodiments, the control systems provide for braking of the vehicle including a full stop by allowing the vehicle operator to close the supply conduits supplying pressurized gas to the prime mover.

It is noted that the pneumatic drive systems of some embodiments are resistant to moisture, dust and heat. Furthermore, pneumatic prime movers are generally considered explosion proof and can be used safely in many hazardous environments.

The pneumatic drive systems of the present invention obviate the need to use heavy batteries, which must be changed every one to two years. In exemplary embodiments, a storage tank of aluminum, steel or composite is used, and the total weight of the storage tank and compressed gas is about 30% less than the weight of a comparable battery. It is noted that the operating life of the storage tank is substantially unbounded.

These and further embodiments will be apparent from the detailed description and examples that follow.

It should be noted that although the description and figures herein are in reference to a powered wheelchair, this is not intended as a limitation and many other vehicle embodiments such as, but not limited to bicycles, two, three and four wheeled scooters, and golf carts, may be powered by the propulsion system of the present invention.

Referring now to the drawings, Figure 1, illustrates a general schematic of a pneumatic drive that includes a pair of ground-engaging drive wheels 1, crank arms 6 that are rigidly attached to the respective semi-axle 4, or alternately to the hub, of the associated drive wheel 1 and double-acting pneumatic actuators 7. The cylinders rotate on swivels 12 fastened to the vehicle body (not shown). Reciprocating motion of the cylinder pistons and rods causes rotation of the crank 6, and through semi-axle 4, drive rotation of the wheels. Vehicle steering is provided by rotating the drive wheels at different speeds, in the same direction or in opposite directions, which is controlled by the control mechanism 11. A supply of pressurized gas is delivered to the control mechanism 11 and then to the respective actuators 7 through gas supply lines 10.

Figure 2 illustrates a wheelchair equipped with a pneumatic propulsion system that comprises a wheelchair body 4, high-pressure storage reservoir 9 for storing compressed gas and providing a supply of pressurized gas such as compressed air, for example, and a pair of double-acting pneumatic cylinders 7, which are fastened pivotally to the wheelchair back structural frame. The reciprocating rods of cylinders are connected with a crank arm 33 associated with a driving wheel axle 21 and 28. Crank arm 33 translates reciprocating motion

of the cylinder rods into rotation of the driving wheels 1. When the piston and rods undergo reciprocating motion, the cylinders pivot on the corresponding swivels 50. Two pairs (one pair illustrated on the right armrest) of levers 27 and 35 are connected to the control mechanism 17 and control the corresponding left and right wheels independently. Levers 27 control wheel speed, while levers 35 control the direction of wheel rotation, as will be discussed below with regard to Figure 4.

Storage tank 9 may be recharged by a standard air compressor, which can be built-in to the wheelchair structure or provided separately. The storage tank 9 may be recharged while still deployed on the wheelchair 4. Alternately, the depleted storage tank 9 may be removed and a full storage tank deployed on the wheelchair 4. Therefore, the wheelchair 4 may also be configured to carry extra storage tanks.

The drive wheels may be equipped with optional push rims 53 for manually propelling the wheelchair 4. Since the pneumatic drive can be easily mounted to, and removed from, the wheelchair, the embodiment illustrated in Figures 2 and 3 can be considered a power-assist device.

A wheelchair version equipped with two single-acting prime movers, such as fluidic muscles for example, is illustrated in Figure 3. It should be noted that structural elements of the present invention illustrated in both Figures 2 and 3 that serve the same or similar functions are numbered the same in both figures. Fluidic muscles 7a are fastened at their upper ends to the wheelchair back structure. Lower muscle ends are connected pivotally with levers 33a belonging to one-way clutches 21a. Contraction stroke of the muscle turns the clutch and correspondingly the driving wheel. During the expansion stroke of the muscle, the clutch is idle. Thus, the one-way clutch transfers reciprocating motion of the single-acting actuators into interrupted (pulse) rotation of the driving wheel in one direction.

Figure 4 provides a not-to-scale schematic diagram of the functional layout of the exemplary propulsion system employing double-acting pneumatic actuators. The propulsion system includes drive wheel 1, illustrated here at a reduced scale, drive wheel axle 3, crank arm 6, cylinder rod 10, double acting pneumatic cylinder 13 with outlet openings 33, cylinder pivot connection 117, two manual-controlled valves 19 for forward and backward motion shifting, direction lever 22 that operates valves 19 for forward and backward motion shifting, automatically-controlled synchronization valve 25, storage tank 29 containing stored compressed gas, control cam 30, conventional gas flow rate control valve 39 that is

controlled by speed control lever 27, and conventional gas pressure regulator 135, which is common for both left and right drive wheel systems of the vehicle.

The exemplary system operates in the following manner. Air or another compressed gas is stored in storage tank 29 at high pressure (about 200 bars). Pressure is decreased by conventional pressure regulator 135 up to about 6-8 bars, and is supplied to flow rate control valve 39, which is controlled manually by speed control lever 27. Low-pressure air then flows to automatically controlled valve 25, providing an alternate supply of pressurized gas to both chambers of the cylinder 13. To do so, the piston of valve 25 is driven by cam 30 that is rigidly fastened on drive wheel axle 3 of drive wheel 1.

Let us assume that in order to provide forward motion to the vehicle it is necessary to rotate the drive wheel 1 in a clockwise direction. In this case, crank arm 6 must be pulled for a first half of a full revolution of drive wheel 1, and crank arm 6 must be pushed for a second half of the full revolution of drive wheel 1.

Cam 30, which is fastened to drive wheel axle 3 (illustrated here as a dashed line 3a), moves the piston of the valve 25 within each wheel revolution so as to provide the cylinder with two-stroke power operation (two piston power strokes per one crankshaft revolution) by redirecting the flow of pressurized air sequentially to the chambers 13b and 13c on opposite sides of piston 13a. The crank arm 6 is pulled during the first half of drive wheel revolution by movement of piston 13a in a first direction and the crank arm 6 is pushed during the second half of drive wheel revolution by movement of piston 13a in a second (opposite) direction.

To drive the vehicle in reverse, drive wheel 1 will rotate in a counter clockwise direction and it is necessary to push the crank in the first half of drive wheel rotation and to pull the crank in the second half of drive wheel rotation.

To this end, valves 19 are controlled by the vehicle occupant through lever 35 and provide shifting between forward or reverse wheel rotation. If pistons of the valves 19 are in the position shown on Figure 4, then pressurized air flows through valve 19a to the left chamber 13b of cylinder 13 when crank arm 6 is positioned in the first half of drive wheel revolution (as illustrated), and through valve 19b to the right chamber 13c when the crank arm 6 is positioned in the second half of drive wheel revolution. Thus, the vehicle travels in a forward direction.

If pistons of valves 19 are shifted to the opposite position of that shown in Figure 4 by forward/reverse direction lever 35, then pressurized air flows through valve 19b to the

right chamber **13c** of cylinder **13** when crank arm **6** is positioned in the first half of drive wheel revolution, and through valve **19a** to the left chamber **13b** when the crank arm **6** is positioned in the second half of drive wheel revolution. As the result, the drive wheel is rotated in counter clockwise direction, and the vehicle travels in reverse.

In order to steer the wheelchair, one of the drive wheels **1** is rotated faster than the other by adjusting the flow rate to one of the drive wheels **1** using the corresponding speed control lever **27**, causing the vehicle to turn toward the slower drive wheel. In contrast, to turn the vehicle about a turn axis located between the drive wheels **1**, the wheels must rotate in different directions. To do so, forward/reverse direction levers **35** located on the left and right sides of the vehicle are shifted by the occupant such that the corresponding drive wheels will rotate in opposite directions.

Thus, a pair of levers controls each drive wheel. One lever **27** controls the frequency of the piston strokes and consequently the rotational speed of drive wheels **1** by controlling the flow rate of pressurized gas through a flow rate control valve **39**. Another lever **35** provides forward/reverse direction shifting. It will be appreciated that the levers described herein are provided only for illustrative purposes and are not intended to be limited. Indeed, there is a possibility to provide this functionality with a single joystick for each drive wheel, or a single joystick arrangement to control both wheels.

Figure 5 illustrates a kinematical layout of the proposed wheelchair propulsion system equipped with one reciprocating prime mover **216** and braked differential steering device using a substantially standard open differential as is known in the art. As illustrated here, the reciprocating prime mover is a double-acting pneumatic actuator **216**, which is fastened pivotally at one end to the wheelchair body (not shown). The other end of the actuator **216** is linked to a crank arm **207** attached to the differential input pinion gear **219**, which engages the differential ring gear **220**. Ring gear **20** is rigidly connected to the differential satellite cage **236** that houses the differential spider gears (not shown). Output differential shafts **211** and **232** are connected through coupling **226** to the semi-axes **206** of the drive wheels **205**. Two brakes **217** are installed with one associated with each of the drive wheels **205**.

When the vehicle is driving straight down, the differential drives both drive wheels at the same rotational speed. In the turning process one of the brakes is applied, the corresponding drive wheel is slowed, and the differential, therefore, acts to rotate the other drive wheel faster.

Practical application of the braked differential propulsion system can be better understood as illustrated in Figure 6. As illustrated here, double-acting actuator **216** is linked to, and generates rotation of, the differential **200** that drives the drive wheels **205**. Handle **221** is configured with a speed control mechanism to control the overall rotational speed of the drive wheels, and thereby the general speed of the wheelchair. Individual brake levers **227** are linked to, and control, brake mechanisms **217** associated with each of the drive wheels **205**. Application of brake resistance to one of the drive wheels **205** causes the wheel chair to turn in the direction of the braked drive wheel **205**.

It will be appreciated that the above descriptions are intended only to serve as examples and that many other embodiments are possible within the spirit and the scope of the present invention.

WHAT IS CLAIMED IS:

1. A pneumatically powered light personal vehicle comprising:
 - (a) at least two drive wheels, wherein each of said drive wheels is actuated by a sole pneumatic reciprocating actuator, and each of said sole pneumatic reciprocating actuators is mechanically linked to the corresponding one of said at least two drive wheels; and
 - (b) at least one gas storage reservoir for supplying pressurized gas to each of said reciprocating actuators.
2. The light personal vehicle of claim 1, wherein said reciprocating actuators are single-acting actuators.
3. The light personal vehicle of claim 2, wherein said pneumatic reciprocating actuator is mechanically linked to the corresponding drive wheel by a one-way clutch.
4. The light personal vehicle of claim 3, wherein said one-way clutch is associated with a supplementary transmission mechanism.
5. The light personal vehicle of claim 1, wherein said reciprocating actuators are double-acting.
6. The light personal vehicle of claim 5, wherein said pneumatic reciprocating actuator is mechanically linked to the corresponding one of said drive wheels by a crank arrangement.
7. The light personal vehicle of claim 6, wherein said crank arrangement is associated with a supplementary transmission mechanism.
8. The light personal vehicle of claim 1, further including a control mechanism for controlling rotational speed of said drive wheels.

9. The light personal vehicle of claim 8, wherein said control mechanism includes a valve configured to direct flow of said pressurized gas to a double-acting reciprocating actuator so as to effect power strokes in both directions of reciprocating motion of said double-acting reciprocating actuator, synchronization of said valve with rotation of said drive wheel being effected by a cam mechanism mechanically linked to said drive wheel.

10. The light personal vehicle of claim 8, wherein said control mechanism controls the direction of rotation of at least one of said drive wheels.

11. The light personal vehicle of claim 8, wherein said control mechanism is configured to vary a flow rate of said pressurized gas to one, the other, or both of said pneumatic reciprocating actuators.

12. The light personal vehicle of claim 8, wherein rotation of said at least two drive wheels is effected solely by mechanical components.

13. The light personal vehicle of claim 1, wherein said gas storage reservoir is configured for use with compressed gases.

14. The light personal vehicle of claim 1, wherein said gas storage reservoir is configured for use with liquefied gases.

15. A pneumatically powered light personal vehicle comprising at least one drive wheel, wherein each said at least one drive wheel is actuated by a sole double-acting reciprocating actuator.

16. The light personal vehicle of claim 15, further including a control mechanism for controlling rotational speed of said drive wheel.

17. The light personal vehicle of claim 15, wherein said reciprocating actuator is mechanically linked to said at least one drive wheel by a crank arrangement.

18. The light personal vehicle of claim 15, wherein said crank arrangement is associated with a supplementary transmission mechanism.

19. A pneumatically powered light personal vehicle comprising:

- (a) at least two drive wheels;
- (b) a selective power distribution mechanism for distributing power to one, the other, or both of said drive wheels;
- (c) at least one pneumatic actuator configured to supply power to said selective distribution mechanism; and
- (d) at least one gas storage reservoir for supplying pressurized gas to each said reciprocating actuator;

wherein steering of the light personal vehicle is effected by varying distribution of power to said drive wheels.

20. The light personal vehicle of claim 19, wherein said at least one pneumatic actuator is a single-acting pneumatic actuator.

21. The light personal vehicle of claim 19, wherein said at least one pneumatic actuator is a double-acting pneumatic actuator.

22. The light personal vehicle of claim 19, wherein said selective distribution mechanism is configured to vary a rotational speed of one, the other, or both of said drive wheels.

23. The light personal vehicle of claim 22, wherein said selective distribution mechanism is a braked differential.

24. The light personal vehicle of claim 19, wherein said gas storage reservoir is configured for use with compressed gases.

25. The light personal vehicle of claim 19, wherein said gas storage reservoir is configured for use with liquefied gases.

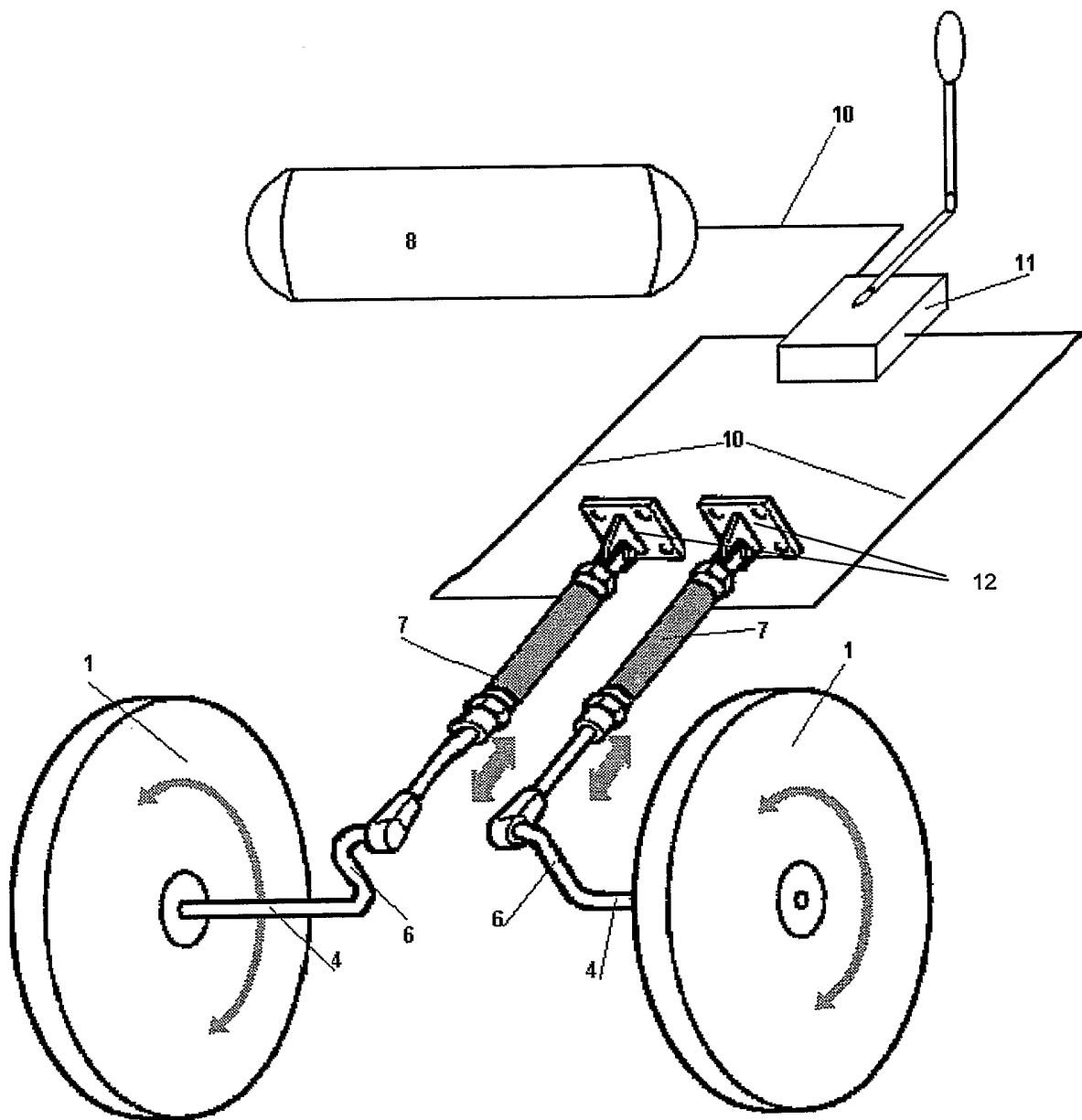


FIG. 1

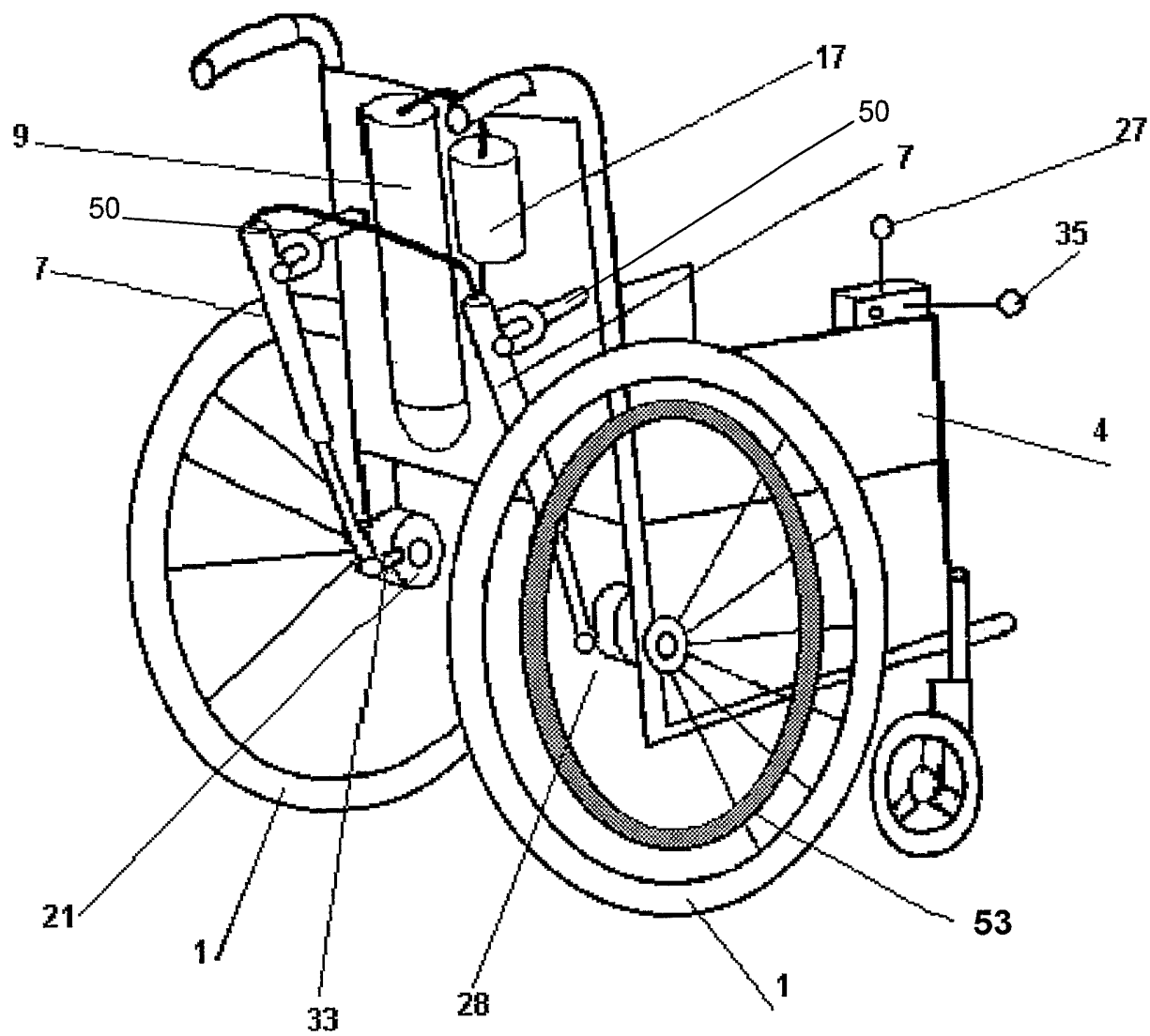


FIG. 2

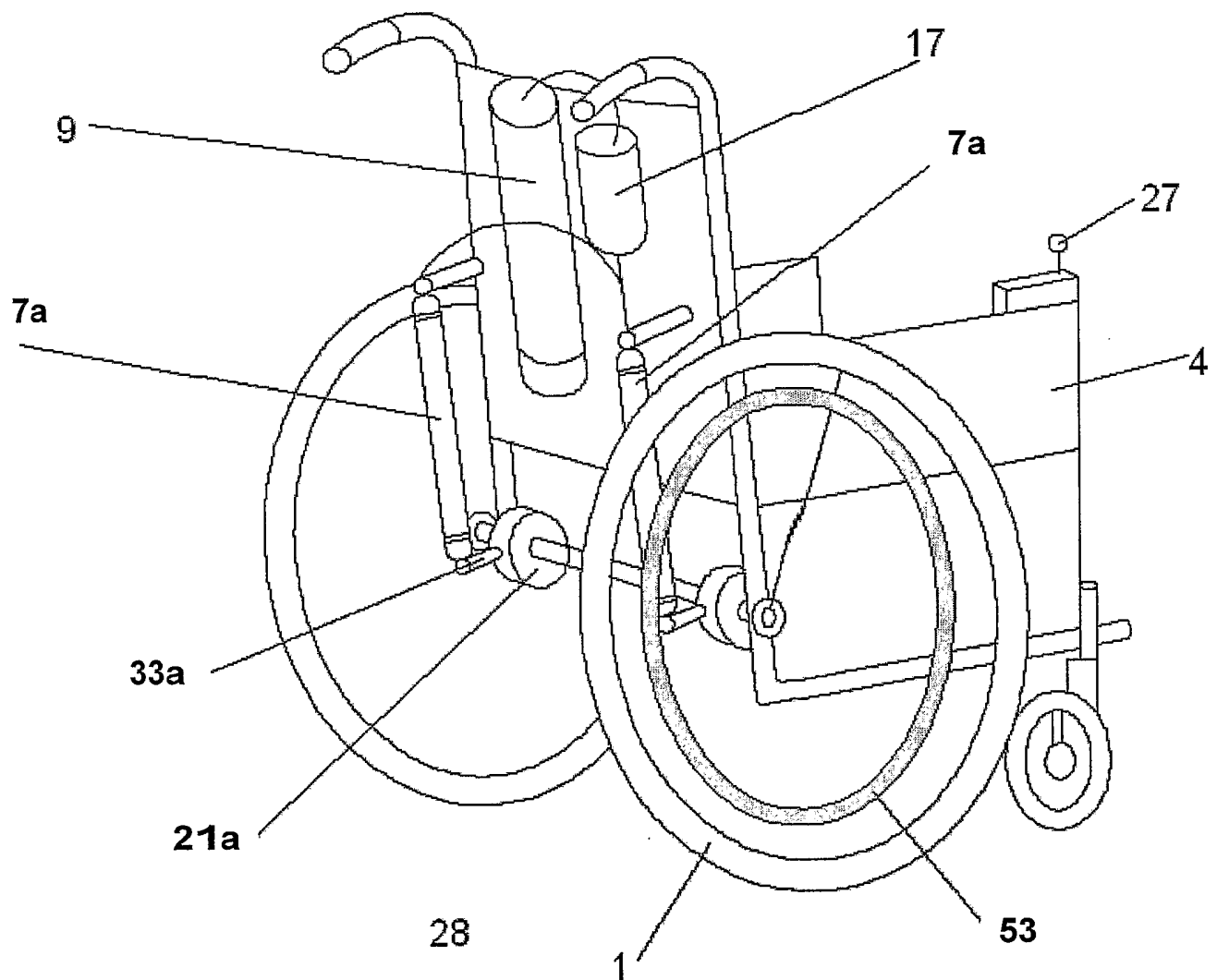


FIG. 3

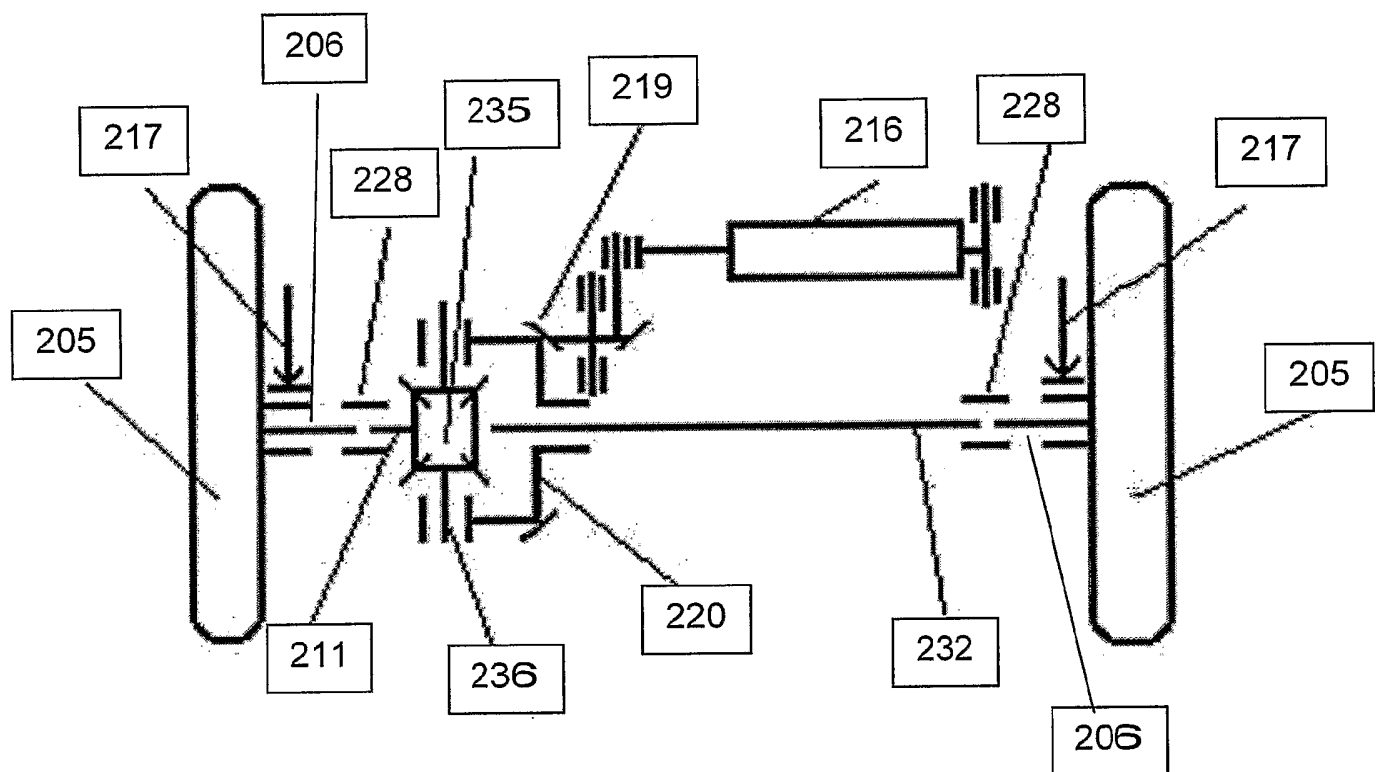


FIG. 5

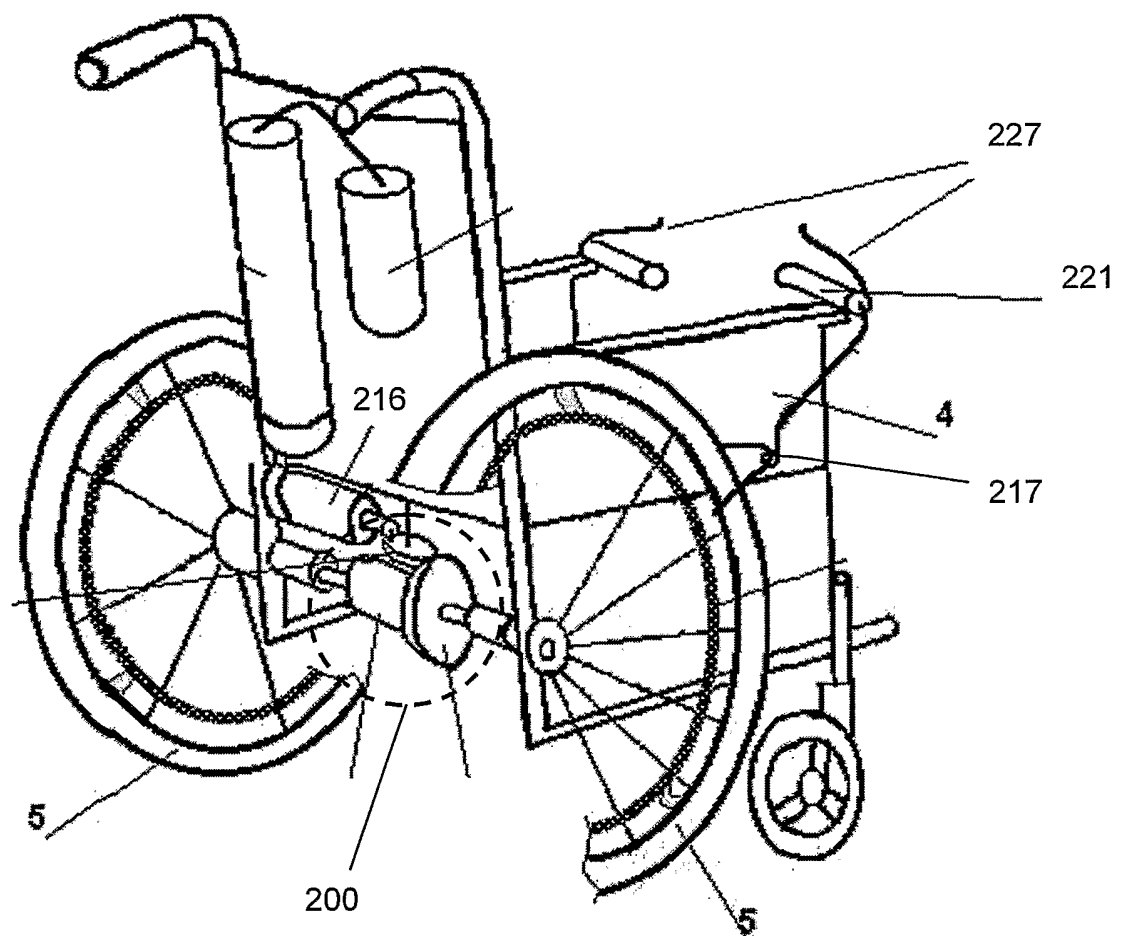


FIG. 6